The Need for a New MV Joint Connector Test Procedure

Presented by:

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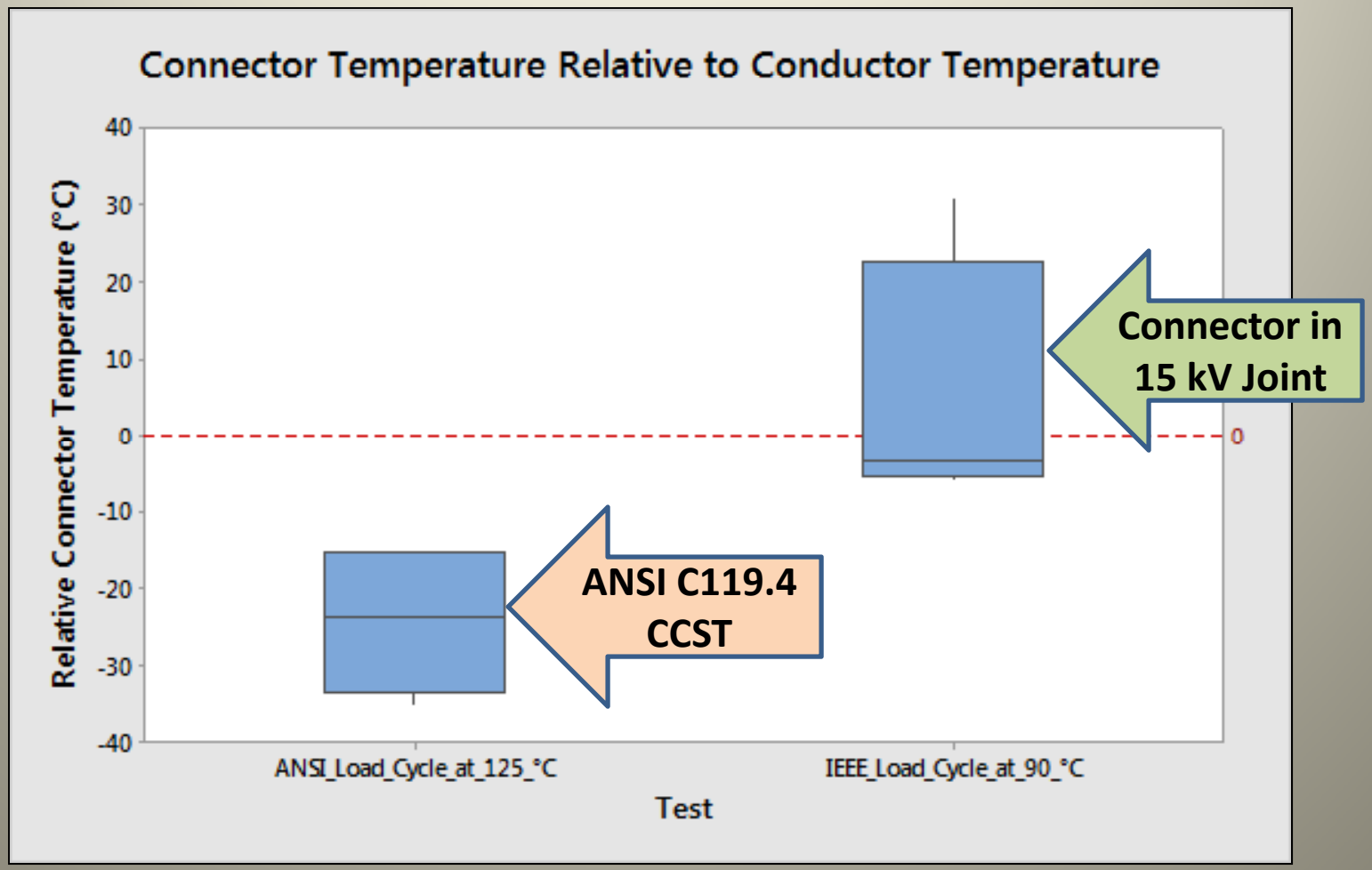
Background

A number of people have been concerned about connectors in joints overheating on highly loaded circuits for years.

Overheating has been observed on circuits that are operated at or near the temperature rating on feeders and generation circuits, typically wind or solar generation where the load varies from no load to full load on a daily basis.

Previous work investigating the impact of strand fill / water blocking materials in MV cable on connector temperatures led us to believe that the ANSI C119.4 Standard may not be appropriate for connectors in joints.

Background

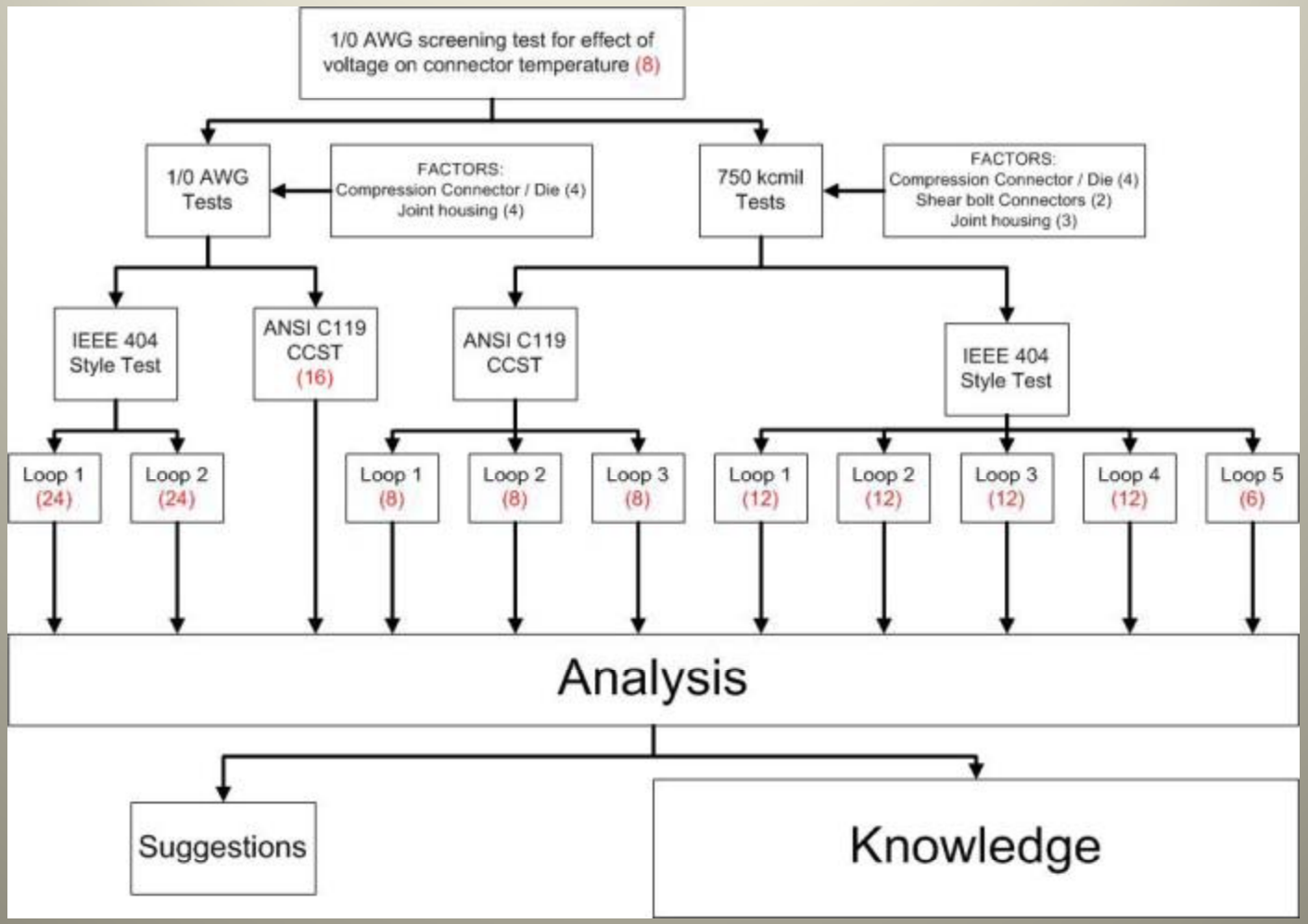

Connector Temperature Relative to Conductor Temperature
Relative Connector Temperature (°C)
40
30
20
10
0
-10
-20
-30
-40
0
Connector in 15 kV Joint
ANSI C119.4 CCST
ANSI_Load_Cycle_at_125_°C
IEEE_Load_Cycle_at_90_°C
Test

Questions

Since we have observed that ANSI C119.4 results do not correlate directly to temperature performance in MV joints, is there a better way to evaluate connectors for use in MV joints?

1. Can we reconcile the differences between ANSI C119.4 test results and the measured temperatures of connectors in joints?
2. Or, do we need to create a new test procedure to evaluate connectors used in MV joints?

Test Program



(#) is the number of samples tested in that step

General Test Details

- All tests were performed using **strandfilled** conductor.
- All connectors were installed using manufacturers' recommendations – manufacturers were contacted directly in some cases for their recommendations before installing the connectors.
- No intentional defects were introduced.

ANSI C119.4
Current Cycle Submersion Test (CCST)

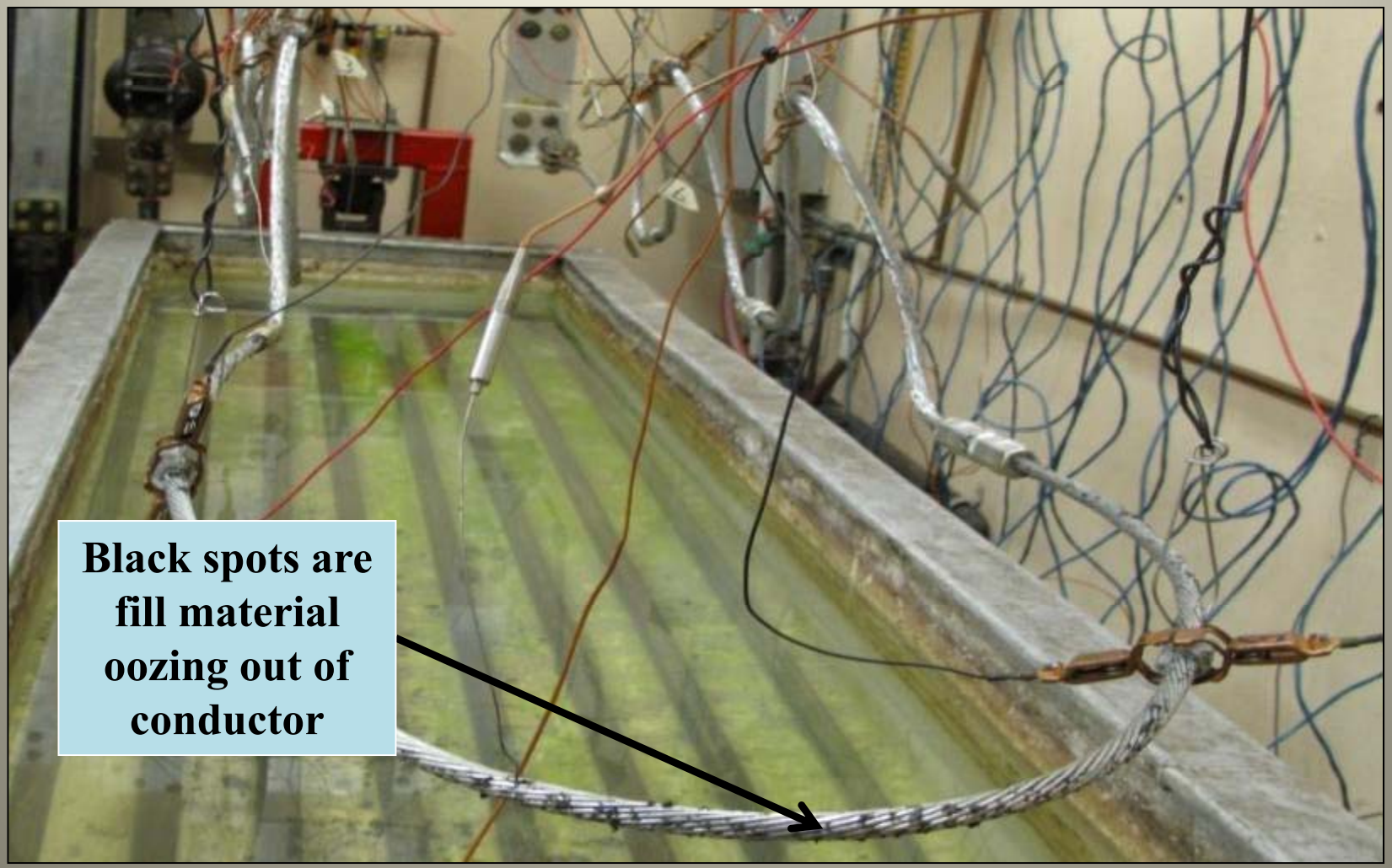
- ANSI C119.4 is currently specified in IEEE Std. 404 for connectors in MV joints
- ANSI C119.4 CCT originally developed for overhead line connectors
- CCST developed as a reduced test time alternative to the 500 cycle test in air
  - Load cycle with current to achieve 100 °C rise over ambient temperature
  - Submerge samples in water at close to 0 °C during current off period

ANSI C119.4
Current Cycle Submersion Test (CCST)

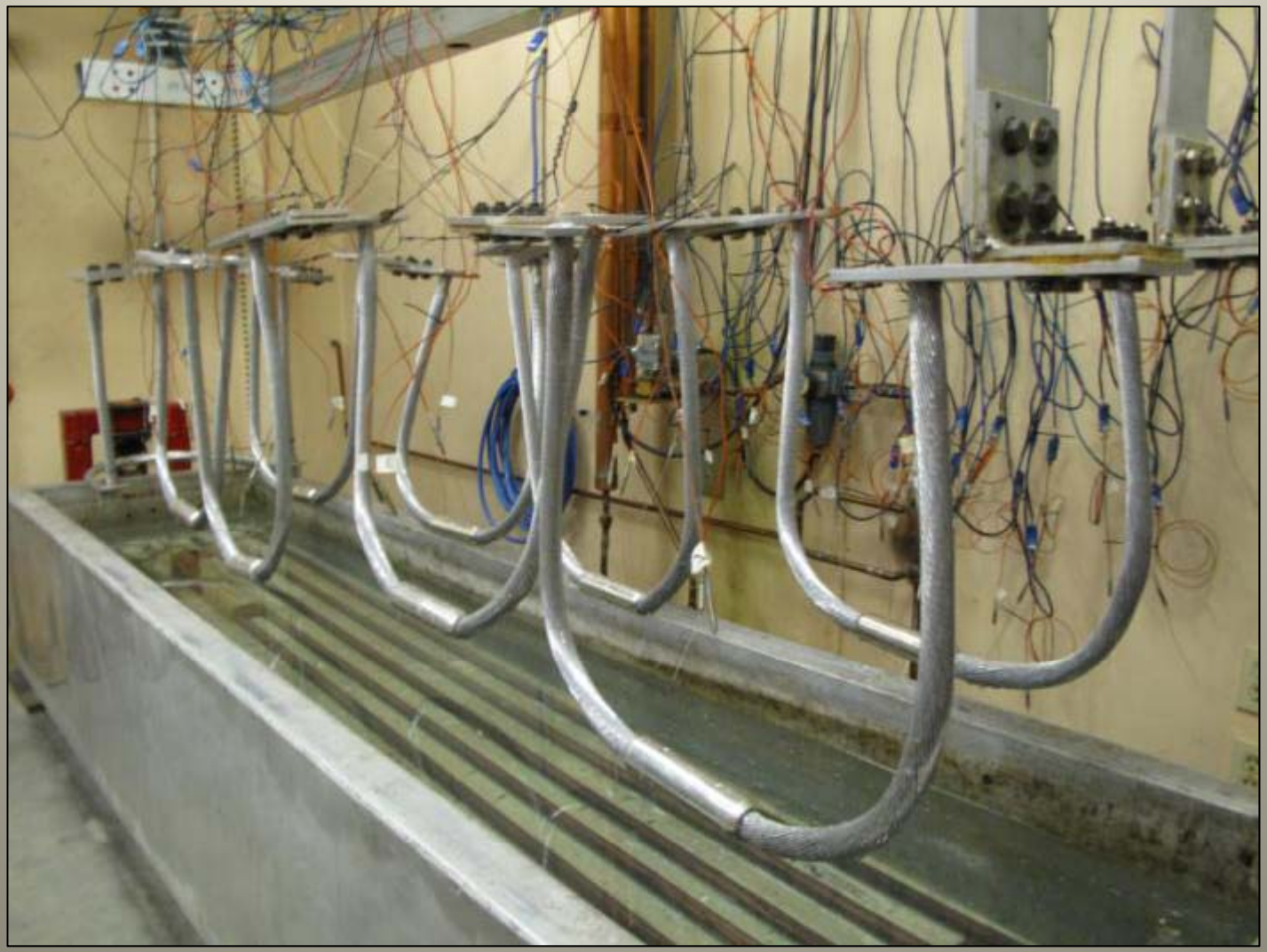
Acceptance Criteria

- Absolute temperature - Connector temperature ≤ control conductor
- Temperature stability - Connector Stability Factor ≤ ± 10 °C of the average temperature difference between the connector and conductor
- Resistance stability - Connector resistance ≤ ± 5% of average

1/0 AWG ANSI C119.4 CCST – Set 1 of 2



750 kcmil ANSI C119.4 CCST – Set 1 of 3



Results Summary - ANSI C119.4 CCST

Based on the acceptance criteria in the standard, twelve of forty total samples did not pass.

4 samples of each connector/die combination tested

Size	Connector	Die	% Connectors Passing			
			ANSI C119.4 CCST (Bare) Conductor ≈ 125 °C			
			Temperature Limit	Temperature Stability	Resistance	TOTAL (Overall)
1/0	A (5/8 size)	Narrow	100 %	100 %	100 %	100 %
	A (5/8 size)	Wide	0 %	50 %	50 %	0 %
	B (840 size)	Narrow	100 %	100 %	100 %	100 %
	B (840 size)	Wide	100 %	100 %	75 %	75 %
750	C	1	100 %	50 %	100 %	50 %
	C	2	100 %	100 %	100 %	100 %
	D	1	100 %	100 %	100 %	100 %
	D	2	100 %	100 %	100 %	100 %
	Shearbolt E	N/A	100 %	75 %	100 %	75 %
	Shearbolt F	N/A	0 %	50 %	100 %	0 %

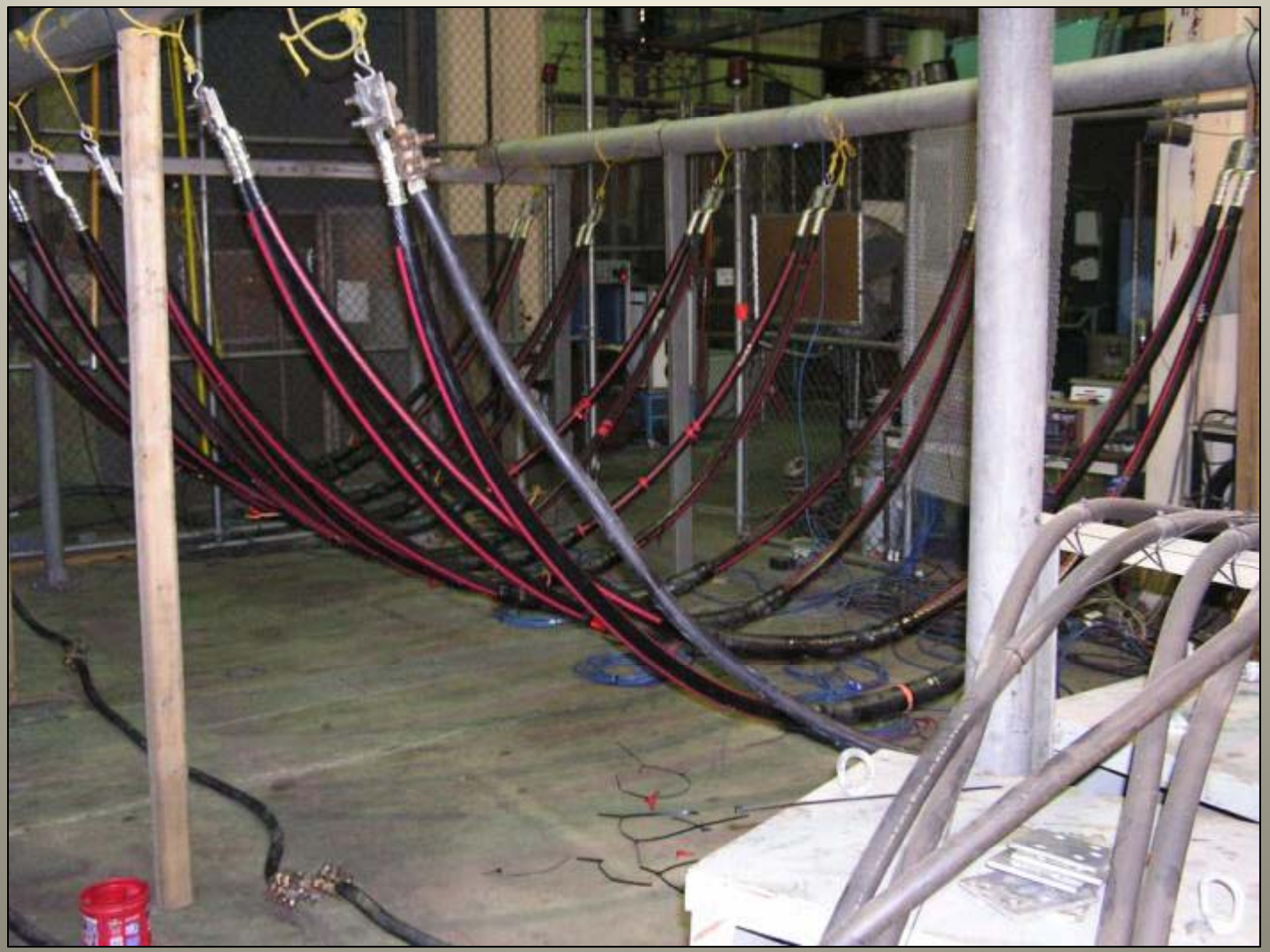
N/A – Not Applicable

IEEE 404 Style Load Cycle Test Connectors Installed in MV Joints

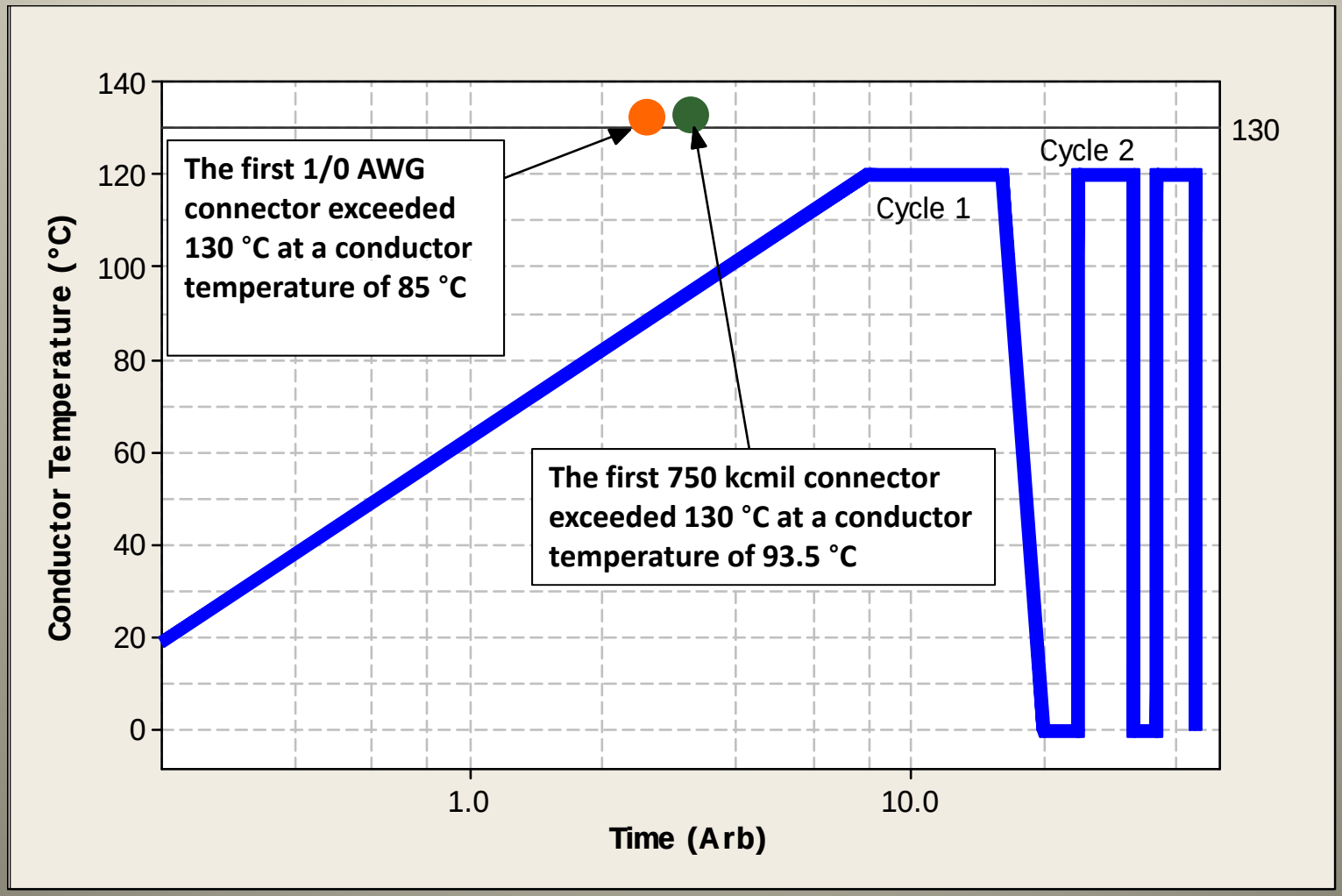
- Installed thermocouples on connectors as the joints were assembled
- Samples constructed without HV terminations as no voltage was applied to test samples
- Load cycle for 100 cycles at conductor temperature of 120 °C
- Sample removed once connector temperature exceeds 130 °C

1/0 AWG IEEE 404 Style Joint Test – Set 1 of 2

750 kcmil IEEE 404 Style Joint Test – Set 2 of 5



Typical Load Cycle Startup

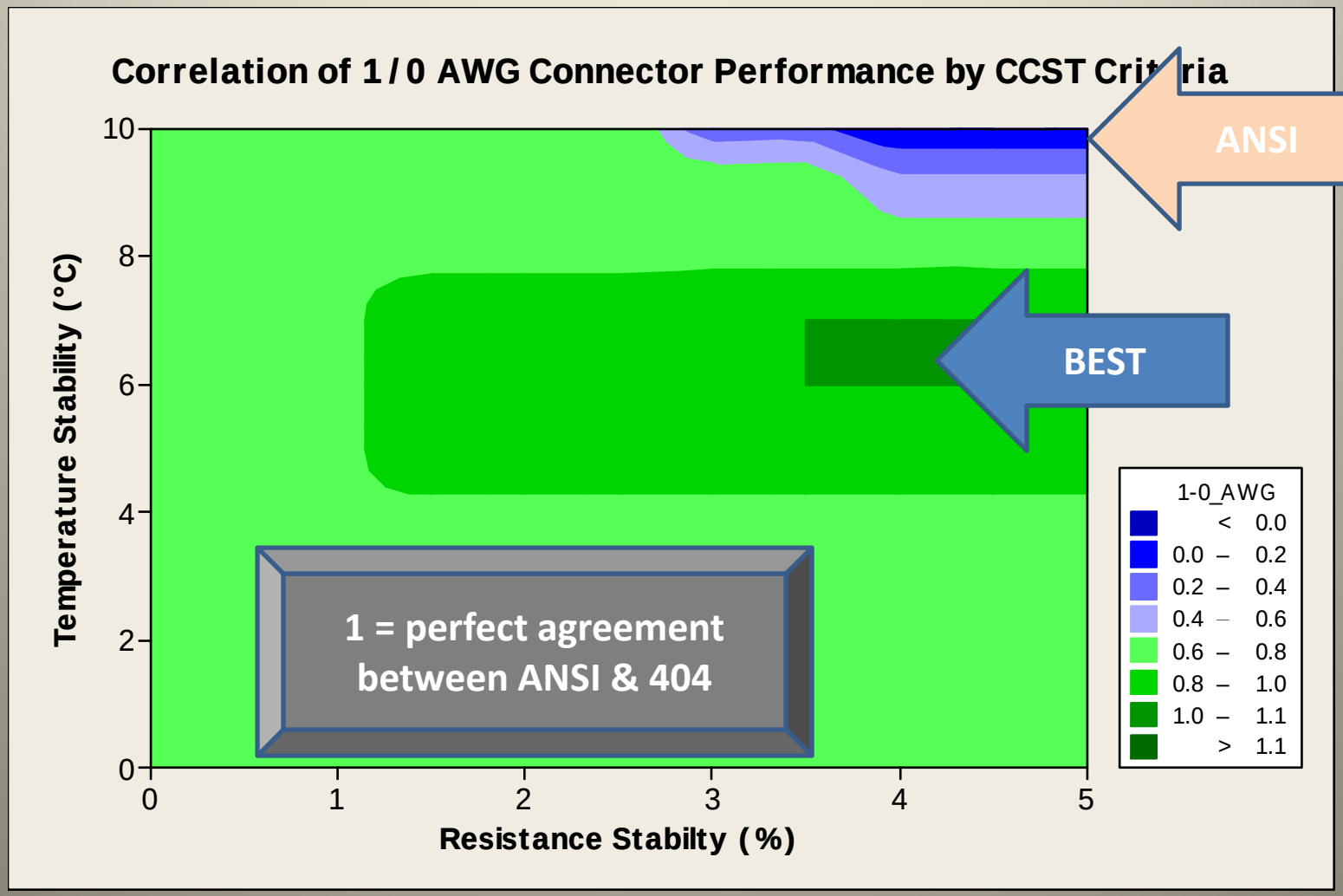


IEEE 404 Style Load Cycle Test Results

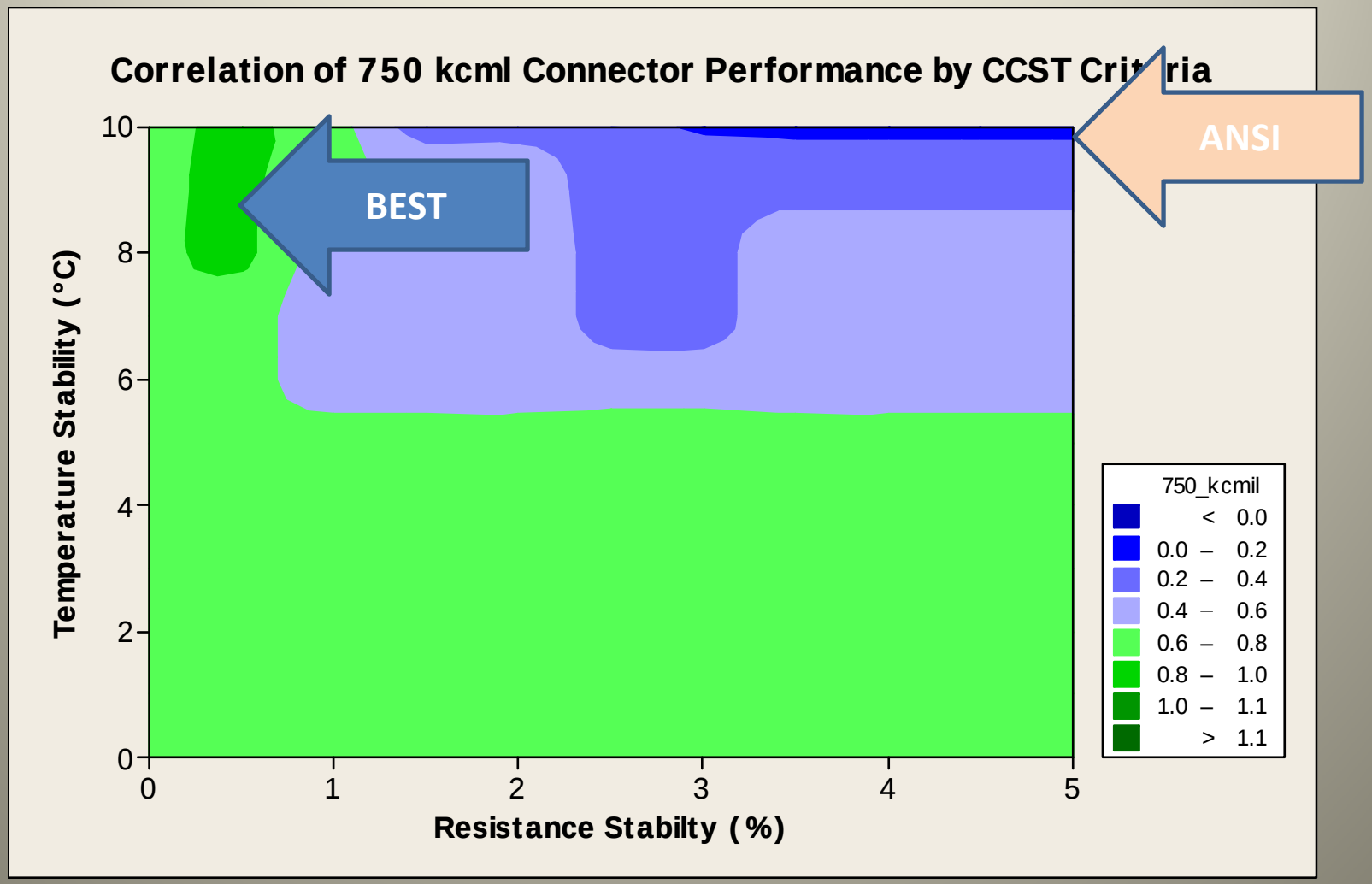
1/0 AWG Joint Connectors (12 of each connector & die tested)			750 kcmil Joint Connectors (9 of each connector & die tested)		
Connector	Die	Connectors ≤ 130 °C[1]	Connector	Die	Connectors ≤ 130 °C[1]
A (5/8 size)	Narrow	**0 %**	C	2	**0 %**
A (5/8 size)	Wide	**0 %**	C	1	**0 %**
B (840 size)	Narrow	**67 %**	D	2	**22 %**
B (840 size)	Wide	**8 %**	D	1	**11 %**
			E (Shearbolt)	N/A	**67 %**
			F (Shearbolt)	N/A	**0 %**

1 – Load cycles with target conductor temperature of 120 °C
N/A – Not Applicable

Test Result Agreement
ANSI to IEEE 404 Style – 1/0 AWG



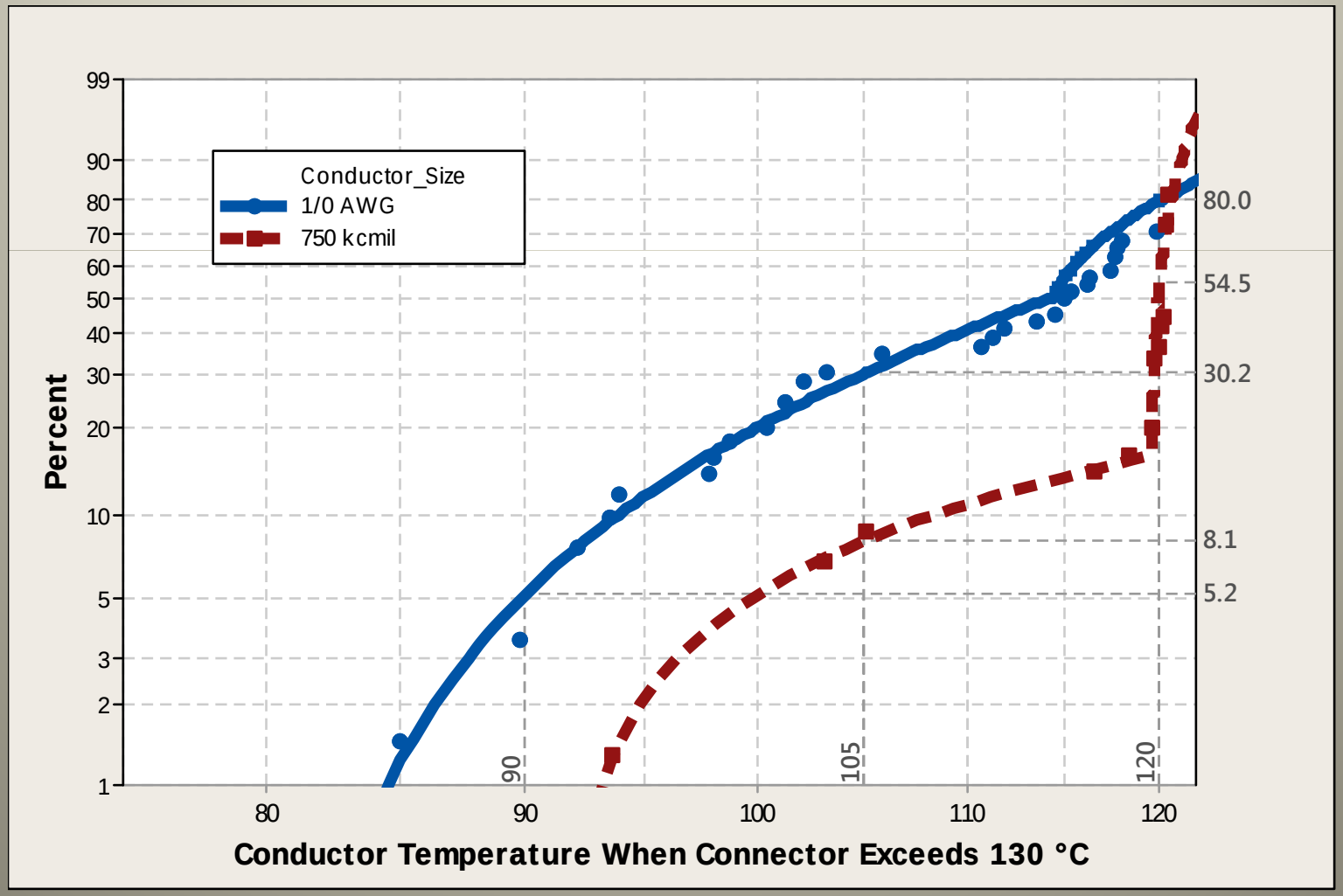
Test Result Agreement
ANSI to IEEE 404 Style – 750 kcmil



Conclusions

1. ANSI C119.4 CCST results did not correlate with measured connector temperatures of an IEEE 404 style test, which better represents how the connectors are used.
2. The acceptance criteria for the ANSI C119.4 CCST cannot be modified to generate results similar to measured connector temperatures in joints.
3. Since other work had indicated that increasing the conductor temperature during an ANSI C119.4 CCST would not help, the only practical solution seems to be to perform a test on insulated connectors using insulated conductor to better qualify connectors for use in underground insulated locations such as joints.

Connector Temperatures by Conductor Temperature



Further Work

1. What temperatures would the connectors in these joints have reached if samples were not removed from the test program when they exceeded 130 C°? (to be presented in the future)
2. What test program should be considered for connectors in joints? (to be presented in the future)
3. Note that we have not looked at:
   - the installation of connectors on field aged MV cable.
   - connectors installed with an incorrect number of crimps
   - connectors installed with known incorrect tool and die combinations

Questions ?