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How Aerospace Technology is Improving the Efficiency, Capacity and Reliability of the Smart Grid

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What we've learned after 10 years of testing, the completion of over 250 projects and the installation of over 22,000 kilometers of ACCC conductor

Background

- Aged Infrastructure
- Congested transmission lines
- Conductor sag can cause short circuit outages
- Line losses are substantial
- Permitting for new lines is very difficult

Outage of 2003 caused by incorrect telemetry data and a race condition computer bug caused three 345 kV line trips due to excessive conductor sag. Several other 138kV lines also tripped due to excessive line sag

Solution

- Develop a high-capacity, low-sag conductor using advanced materials

Challenge

- Utilities are very conservative and slow to adopt new technology
- Substantial testing is required
- In some cases new test protocols need to be developed
- New test protocols often take time to perfect
- Interpretation of accelerated aging test data requires expertise
- Field experience is essential but takes time and substantial commitment

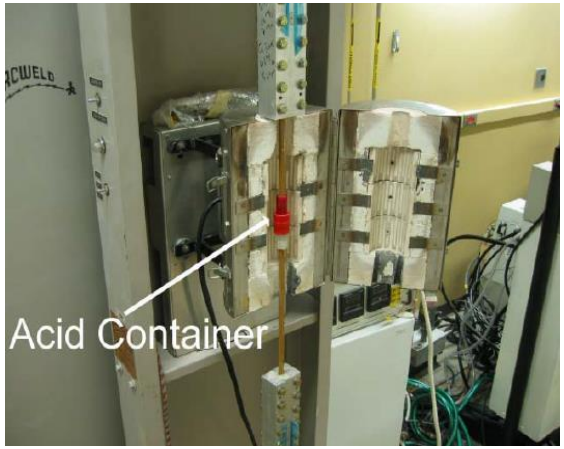
Path to Deployment

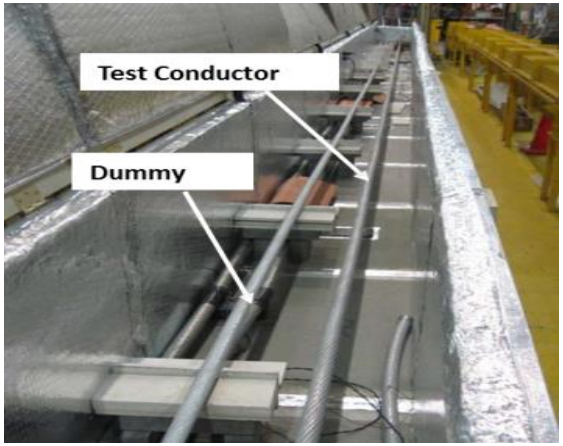
- Developed & Tested the Composite Core
- Tested Electrical Properties of the Conductor
- Developed & Tested Ancillary Hardware
- Assessed Environmental Exposure and Longevity
- Developed Proper Installation Procedures
- Completed First Energized Install at NG in 2005
- Secured “Type Certification” by 100+ Utilities
- Over 250 Projects Completed in 28 Countries
- 15 Additional Projects Underway

Key Technical Questions

- How will the electrical performance compare to other conductor types?
- How will its mechanical performance compare?
- Will hardware components perform as designed?
- Will it be difficult to install or maintain?
- How well will it resistance environmental exposure and fatigue?
- How well will it resist thermal aging and unusual field events?
- What will happen if we run it hotter than recommended?

Lab Work





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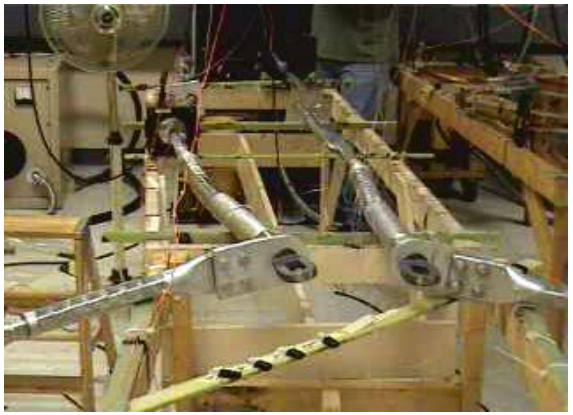
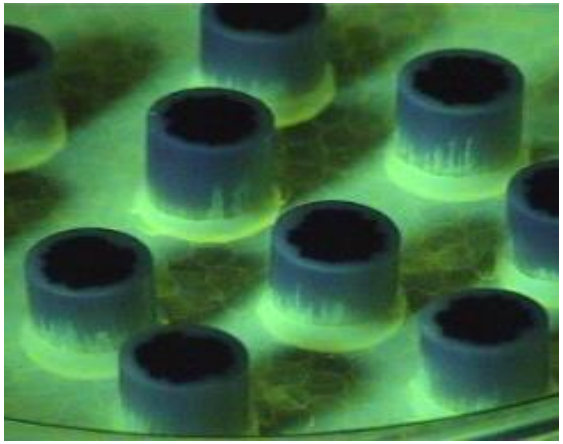
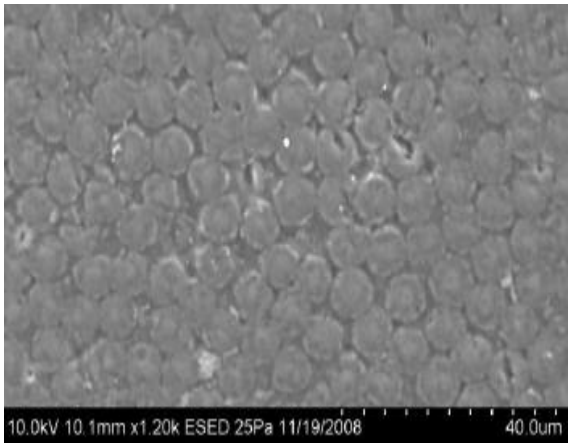
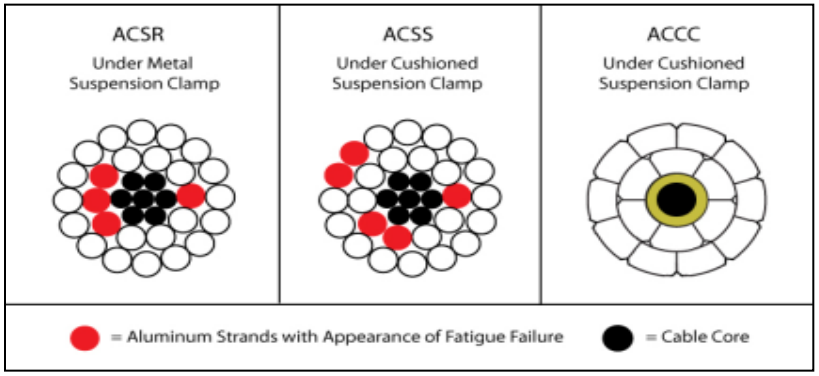
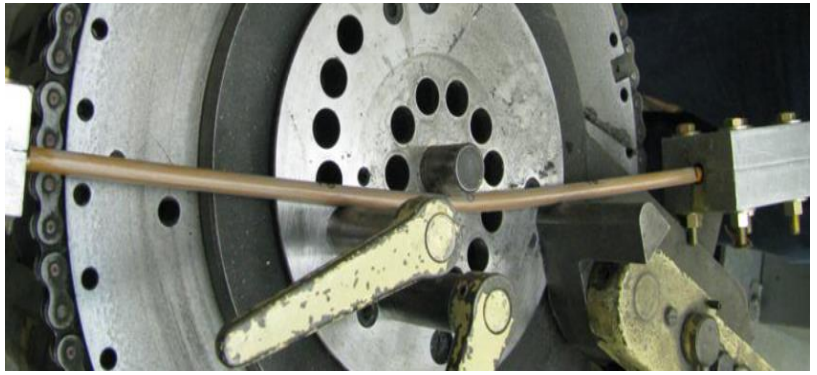


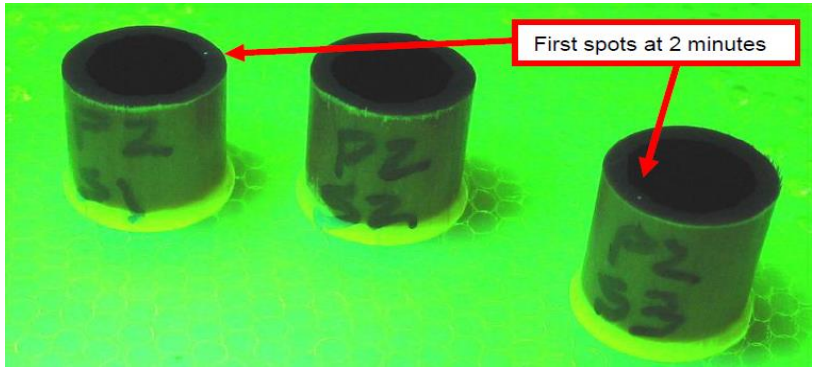




Novel Tests

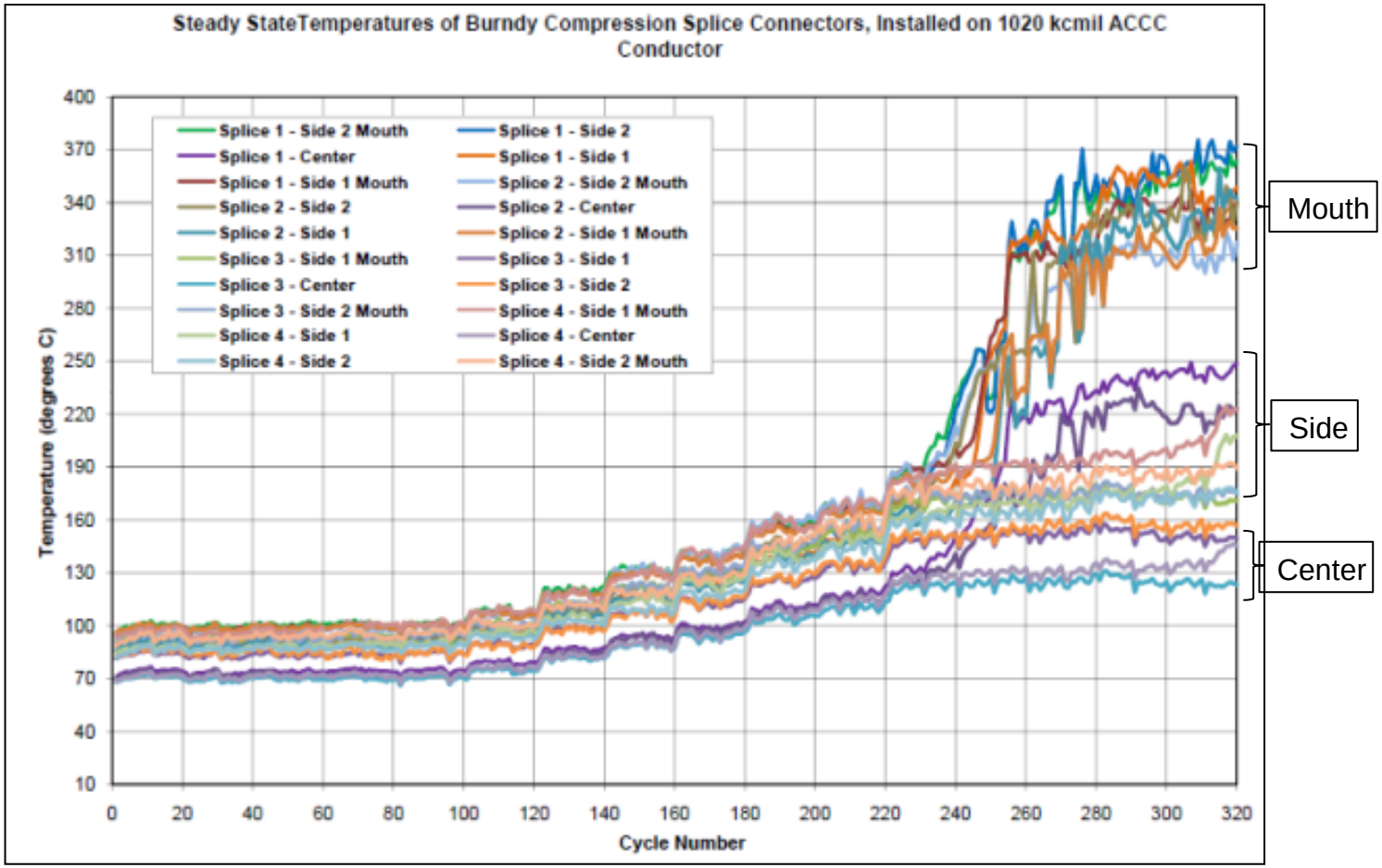






AEP Sequential Mechanical Test

Discovering Upper Limits

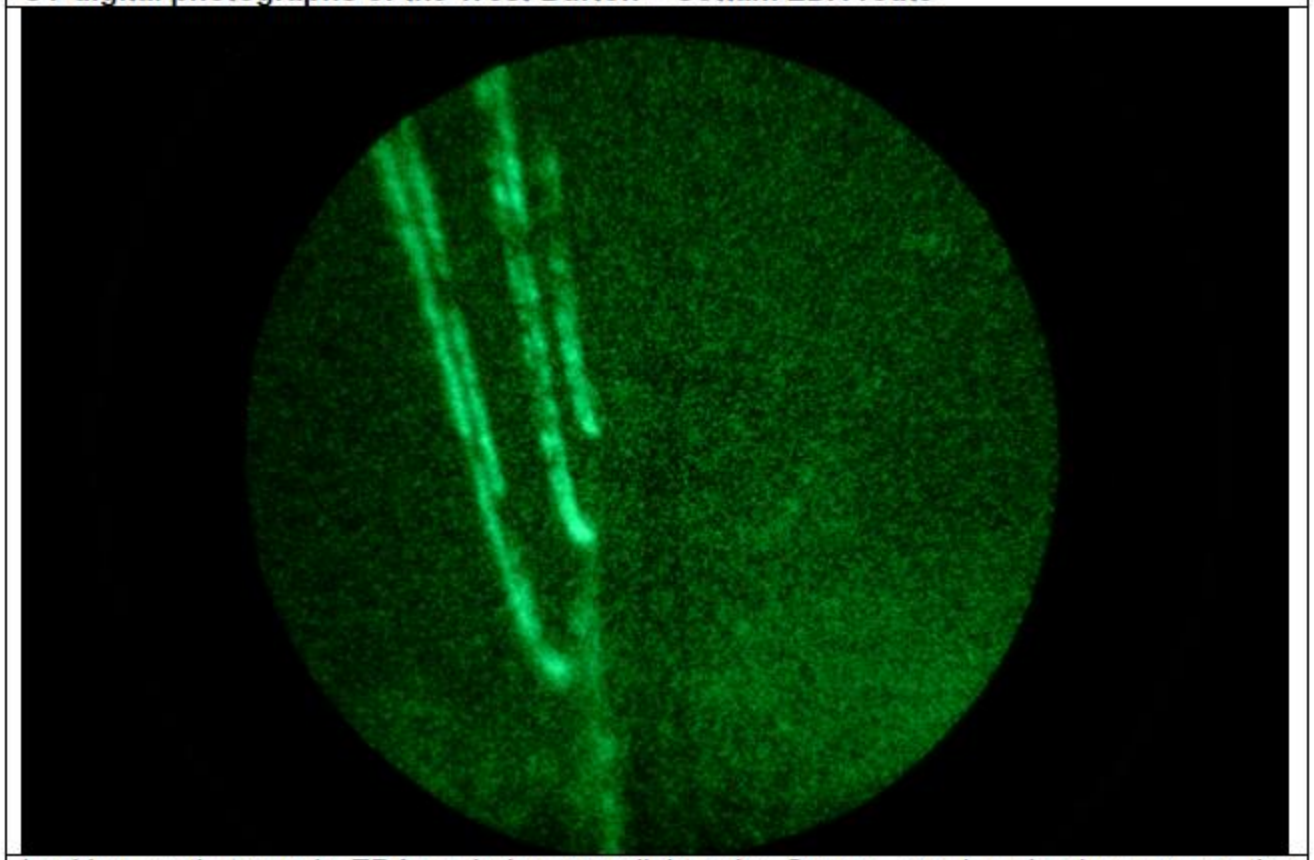


ANSI C-119.7 Hardware Test

Field Measurements

Figure 2; UV Night Scope survey in wet weather

UV digital photographs of the West Burton – Cottam ZDA route



Looking north towards ZDA16 during very light rain. Corona can be clearly seen on the western Rubus circuit. Significantly less corona on the eastern ACCC circuit.

Field Measurements

ACCC “ULS” Oslo compared to ACSR Lynx & AAAC Sycamore at Deadwater Fell Test Site
(ACCC “ULS” offers improved ice-load sag)

Field Experience

Countries:

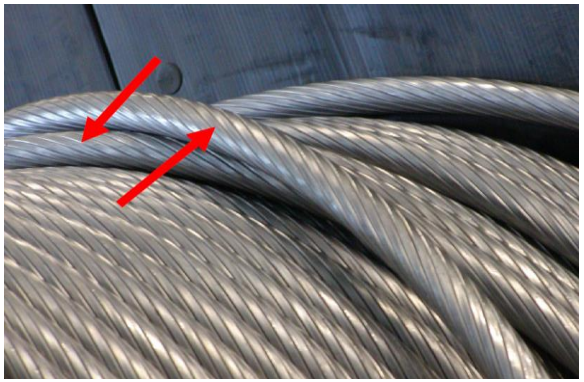
- USA
- China
- France
- UK
- Poland
- Spain
- Portugal
- Mexico
- Chile
- Qatar
- Indonesia
- Belgium
- Brazil
- Germany
- South Africa
- South Korea
- Russia
- India
- Costa Rica*
- Columbia
- Congo
- Mozambique
- Netherlands*
- Nigeria*
- Vietnam

US Utilities:

- AEP
- APS
- PacifiCorp
- NV Energy
- Austin Energy
- Xcel Energy
- MI PUD
- KS PUD
- KAMO
- OG&E
- Ozark Electric
- WAPA
- STEC
- Entergy
- Riverside PUD
- Florida Power & Light
- Keys Energy
- Progress Energy
- Mohave Electric
- SCANA
- National Grid
- Alexandria (LA) PUD

Lessons Learned

- Don’t over bend conductor
- Maintain good reel control
- Maintain good grip during pulling
- Make sure equipment is in good condition
- Don’t allow installed dead-end to fall
- Good training is very important



In Service Events

Extreme winds caused structure to blow over – no damage to ACCC

In Service Events

Heavy ice caused trees to fall over – no damage to ACCC

In Service Events

Fire storm caused structures to burn down – no damage to ACCC

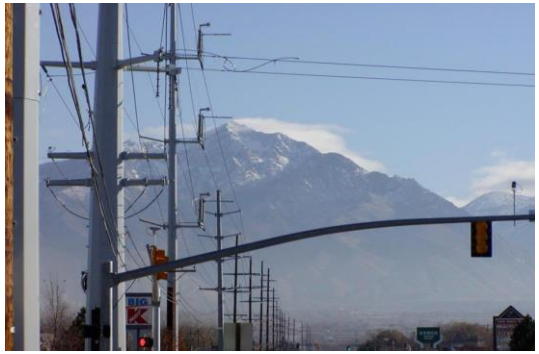
In Service Events

EF5 tornado impact caused structural failure – ACCC core survived

In Service Events

EF5 Tornado impact caused overbuilt line to drop – ACCC undamaged

Applications



Initial Questions & What We've Learned

- How will the electrical performance compare to other conductor types?
  - *Higher aluminum content offers decreased resistance*
- How will its mechanical performance compare?
  - *Improved self damping & greater strength offers advantages*
- Will hardware components perform as designed?
  - *Yes*
- Will it be difficult to install or maintain?
  - *If industry standard guidelines are followed, no problems should occur*
- How well will it resistance environmental exposure and fatigue?
  - *Testing shows excellent resistance to ozone, UV, corrosion & cyclic load fatigue*
- How well will it resist thermal aging and unusual field events?
  - *ACCC has thermal limits (180C max continuous) some exposure to higher temps is ok*
- What will happen if we run it hotter than recommended?
  - *Testing at 215C for (40) eight hour excursions did not impact conductor core or hardware*

Thank you

CTC GLOBAL