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

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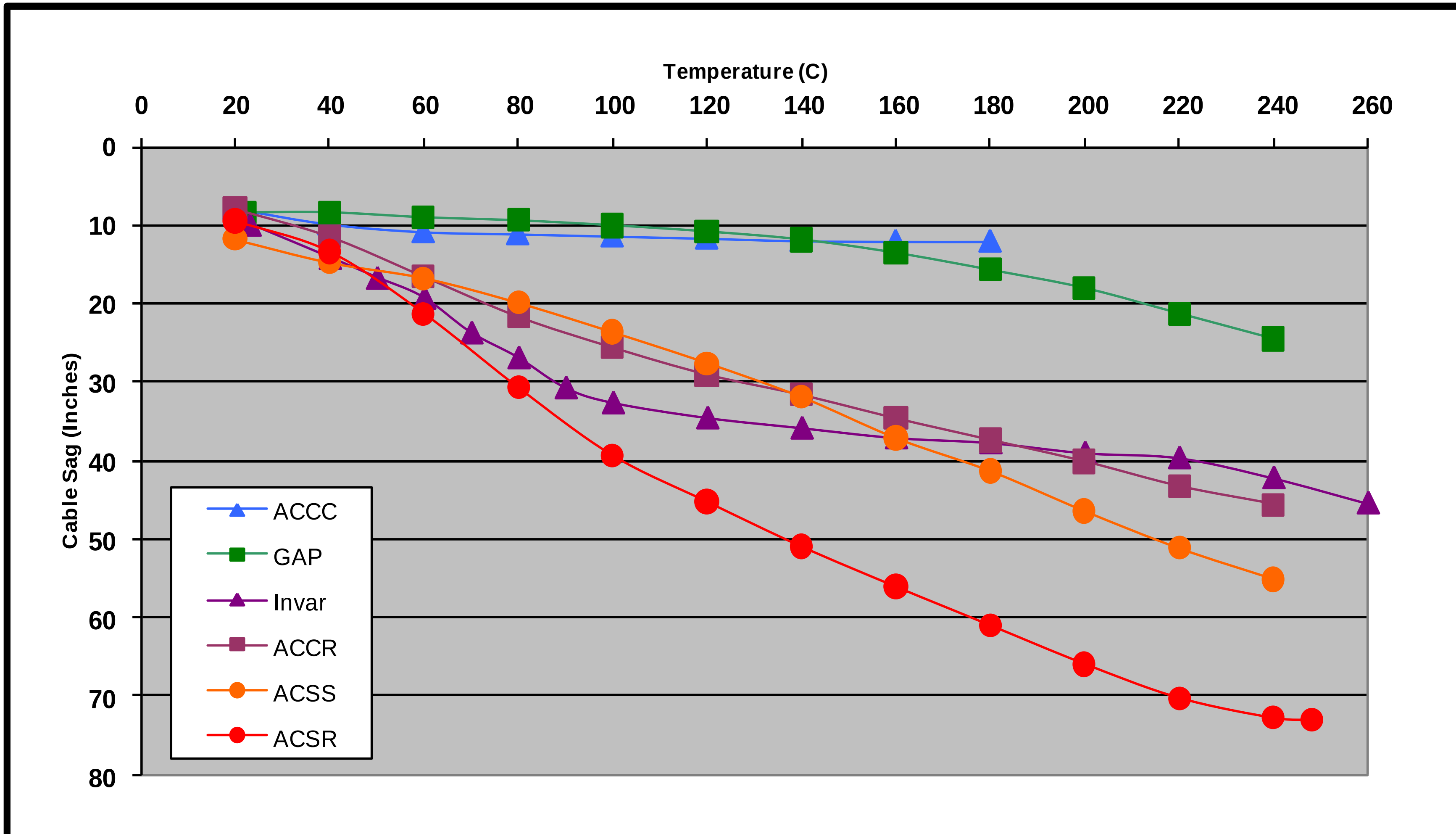
***What we've learned after 10 years of testing, the completion of over 250 projects and the installation of over 22,000 kilometers of ACCC conductor***

# Reflections from the Past

According to the final NERC report, the blackout of 2003 was caused by inaccurate telemetry data, a computer reboot failure, a race condition computer bug and inadequate communication. These events led to the thermal overloading of three 345 kV and several more 138 kV lines wherein excessive conductor sag led to a number of short circuit events and cascading outages. A modern high-capacity, low-sag conductor may have helped prevent the cascading outage.

# Wires are a key component of the grid




Ontario Hydro comparison of sag and temperature of several conductor types

*ACCC offers a reduction of line losses by 25 to 40% or more depending upon load level*

# Why Are Modern Conductors So Important?

- Reduced line losses can reduce fuel consumption, decrease emissions and free up existing generation.
- Increased line capacity can reduce congestion costs and improve grid reliability - especially during an unplanned outage.
- Reduced line sag can prevent sag trip outages and improve grid reliability.
- A substantial component of the grid are its wires. We should consider modern conductors as a key component of our smart grid strategy.

# Modern Conductors offers…

- Greater Strength & Reduced Thermal Sag
- Increased Spans on Fewer / Shorter Structures
- Twice the Capacity of AAAC & ACSR
- Reduced Line Losses by 25 to 40%
- Decreased Fuel Consumption & Emissions
- Free up Existing Generation Capacity
- Reduces Life Cycle Costs

The ACCC conductor’s lightweight composite core allows the incorporation of 28% more aluminum without a weight or diameter penalty using compact trapezoidal strands.

# How the ACCC Conductor Evolved

- Composite Core was Developed & Tested
- Electrical Properties were Measured
- Ancillary Hardware was Developed & Tested
- Longevity and Environmental Exposure Assessed
- Proper Installation Procedures were Developed
- First Line Energized at National Grid US in 2004
- Secured "Type Certification" by 100+ Utilities
- Completed over 250 Projects in 28 Countries
- 15+ Additional Projects Underway



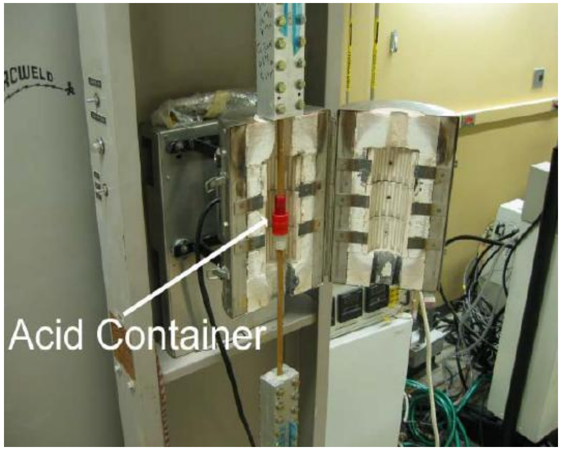


# Lab Experience

Twisted

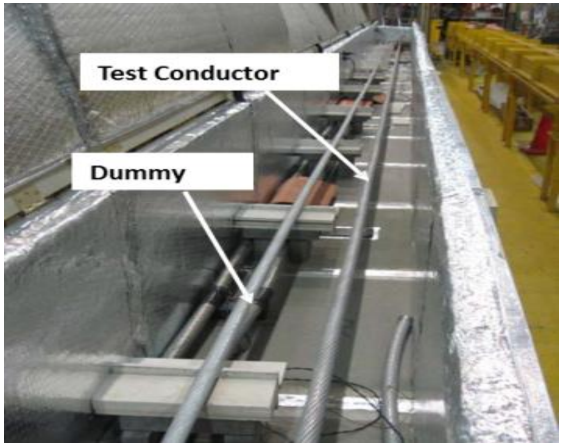
Bent

Soaked




Stressed

Tensioned



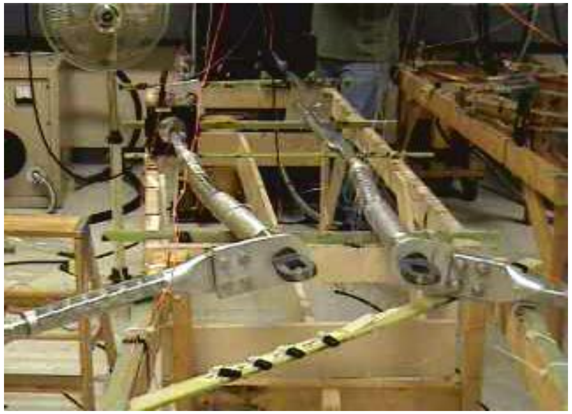

Heated

**US / UK / France / Canada / Mexico / China / Brazil / Chile / Belgium / Indonesia / Germany**

# Lab Experience

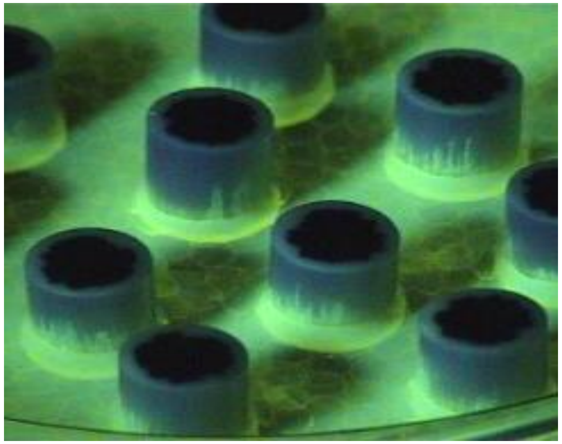
System Tests

Electrical Assessment

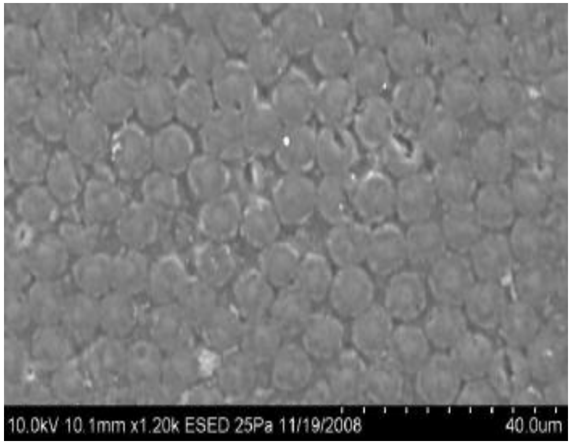


Hardware Tests

Longevity Tests



Post Testing Analysis

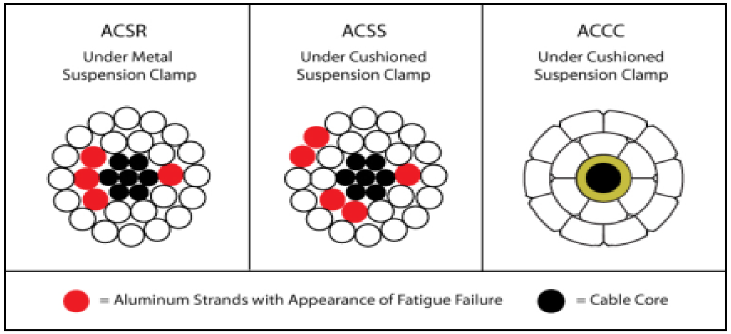



Microscopic Examination

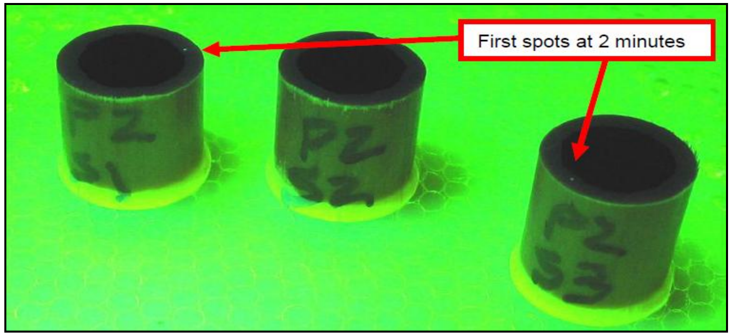
**US / UK / France / Canada / Mexico / China / Brazil / Chile / Belgium / Indonesia / Germany**

# Novel Tests Were Also Developed & Performed

- Pulled conductor over a sheave wheel numerous times to represent installation stress
- Installed on a test span with a suspension clamp at 1/3 span
- Completed 100 million cycles of vibration and 100 thousand cycles of galloping
- Increased tension repeatedly, pulled to failure, evaluated remnants

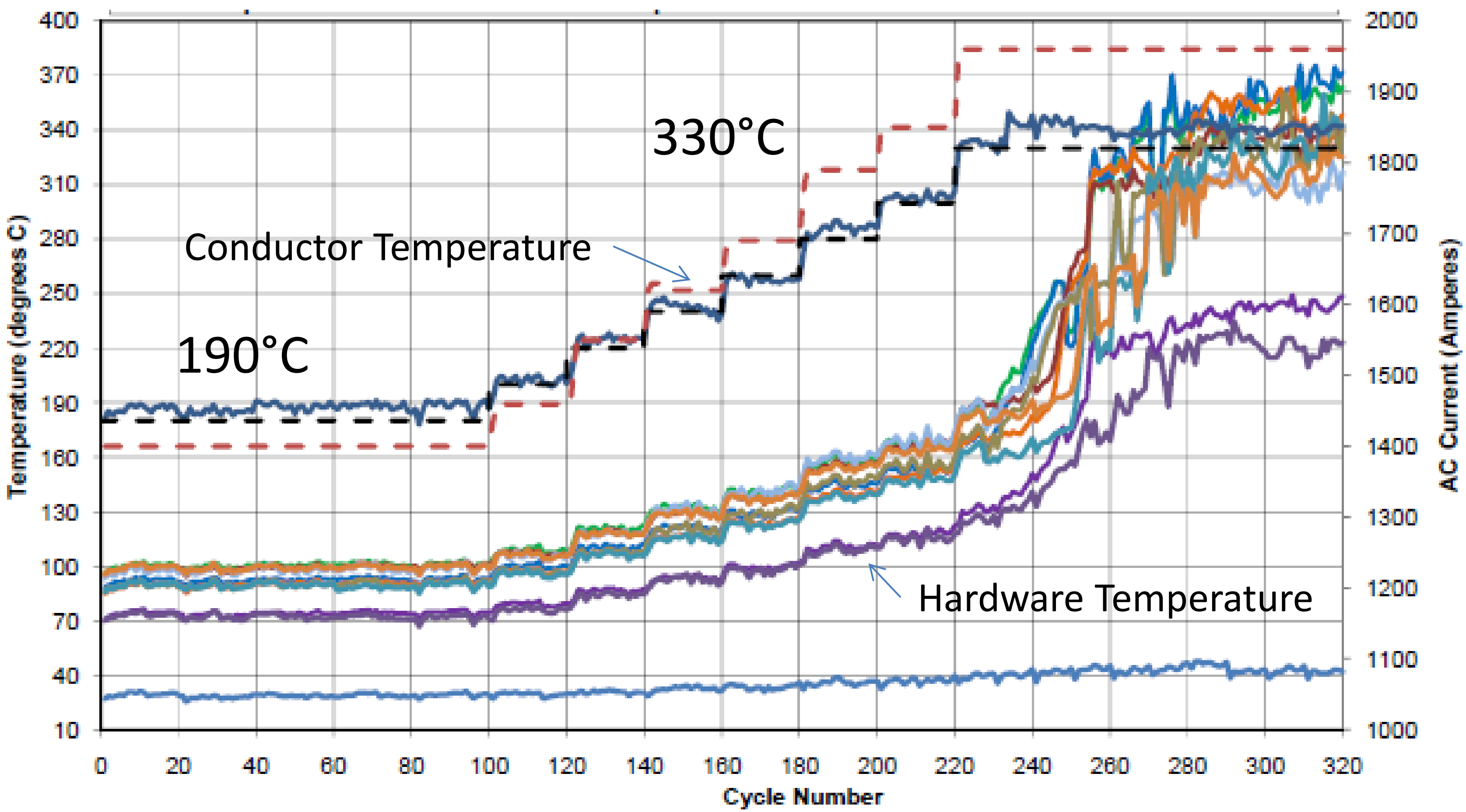



AEP Sequential Mechanical Test




AEP is currently installing 1,440 miles of ACCC at their 9th ACCC project (while the line remains energized)

# Hardware Testing Established Upper Limits

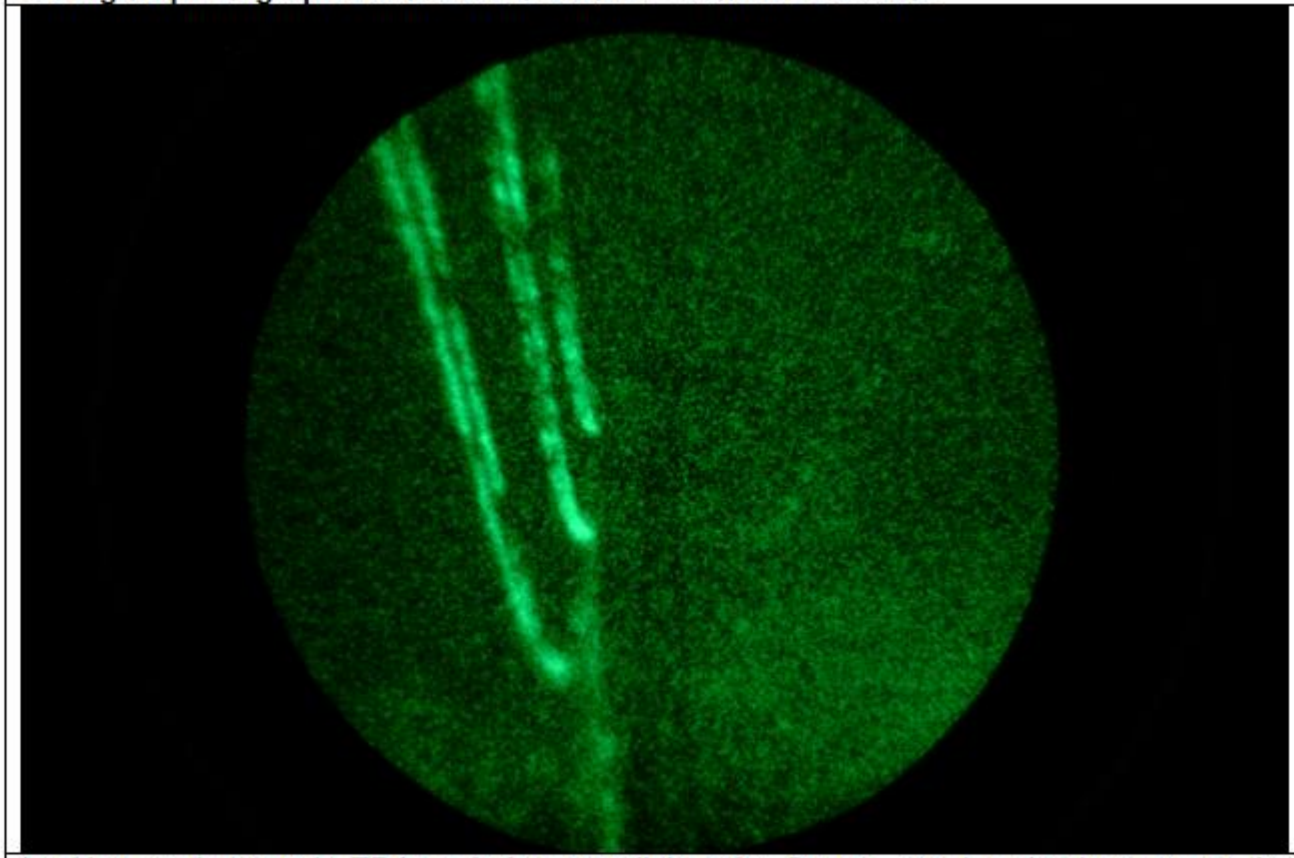



ANSI C-119.7 “Round Robin” Hardware Test

# Field Measurements Validated Performance

**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.

# Ice & Wind Testing Helped Develop “ULS” Conductor Design for Heavy Ice / Long Spans


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

# Experience is Important

>22,000 km at over 250 project sites

**Countries:**

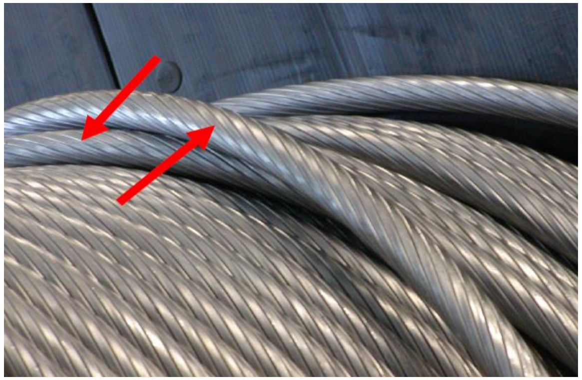
- USA
- China
- France
- UK
- Poland
- Spain
- Portugal
- Mexico
- Chile
- Qatar
- Indonesia
- Belgium
- Brazil
- Germany
- South Africa
- South Korea
- Russia
- India
- Costa Rica*
- Columbia
- Congo
- Mozambique
- Netherlands*
- Nigeria*
- Vietnam

**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

# Installation 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

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

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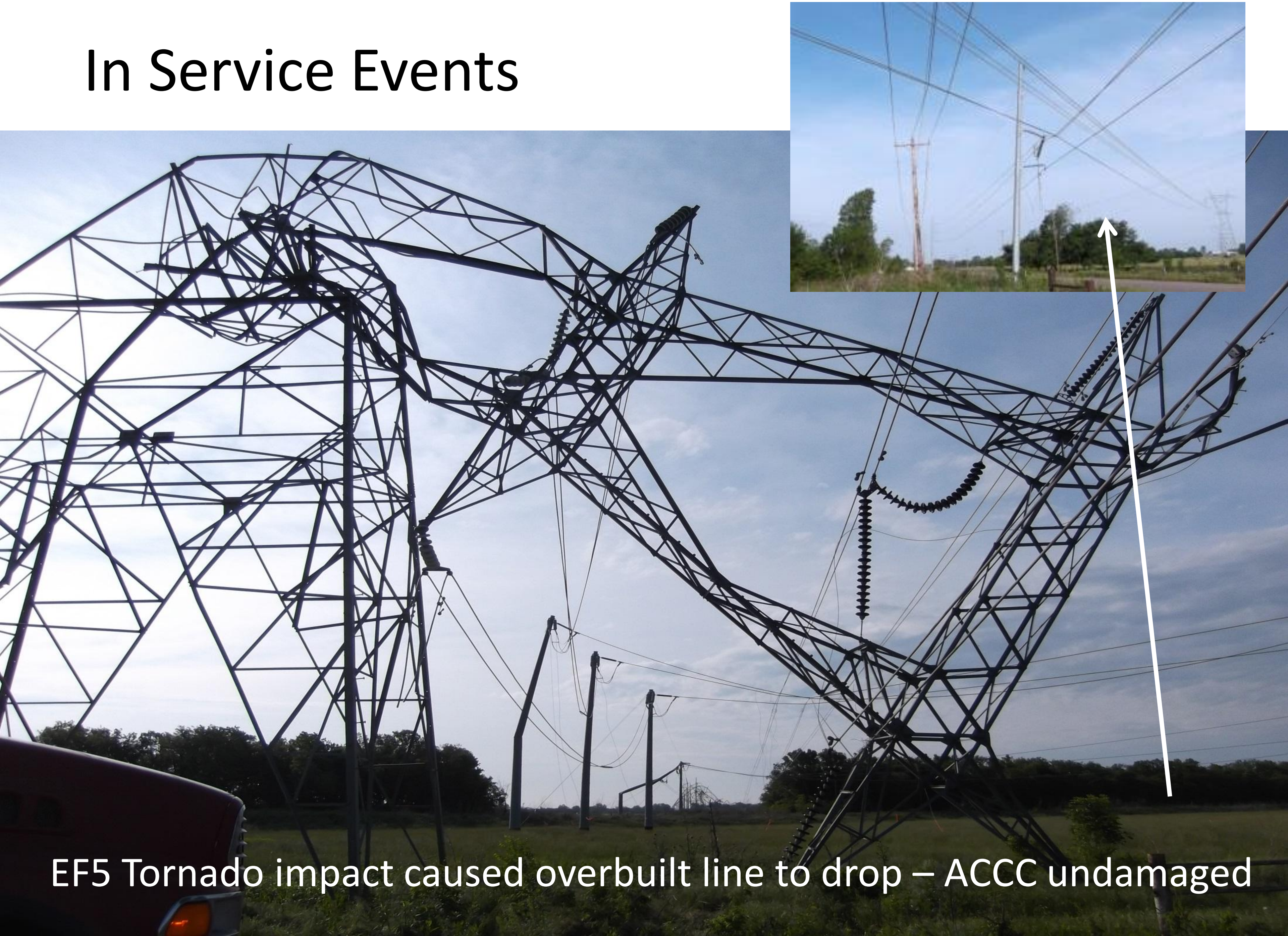
EF5 tornado impact caused structural failure – ACCC core survived

# In Service Events



EF5 Tornado impact caused overbuilt line to drop – ACCC undamaged

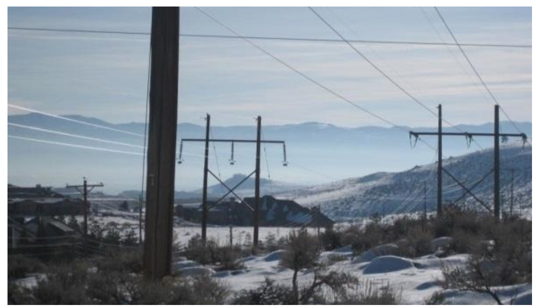
# Successful Applications

Reconductoring

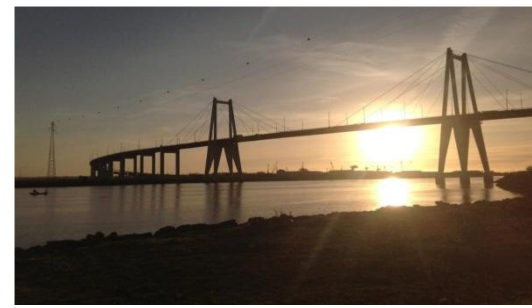
Salt water crossings


Long Spans

Wind Farm Link



Heavy Ice Load (ULS)



River Crossings

UHV

Generation Tie Lines

Capacity Upgrades

# Summary of What We've Learned

- Lab testing is extremely valuable, but many important things are also learned in the field.

- Novel lab tests can offer outstanding insight, but new test protocols can take time to develop, refine and implement.

- Utilities are highly conservative for good reason. Technologies such as ACCC cannot be developed without significant industry involvement.

- Proper installation techniques and equipment can help insure project success.

- Training and onsite support can help circumvent issues that do occur from time to time.


Questions?
CTC GLOBAL