Southwire
HTS Cable Program Overview

2005 U.S. DoE Peer Review
2-August 2005

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Director, Ultera
SPI Project Goals & Objectives:

- **SPI-1: 30-m Installation, Carrollton, GA**
  - The cable system will continue to be operated and studied. Optimizations will be made to improve operating efficiencies and reliabilities.

- **SPI-2: Bixby Substation, AEP, Columbus, OH**
  - To complete a 200 meter demonstration with AEP
    - Install 13.2 kV, $3.0 \text{kA}_{\text{rms}}$ (69 MVA) HTS cable system in Bixby substation, about 2 times the power of the Carrollton, GA demonstration
    - Highest current cable project
    - Length would be on the order of 7 times the Carrollton, GA demonstration
    - Design and install a simplified and reliable cryogenic system based on prior experiences
    - Demonstrate underground installation with field installed cable joints built in underground manhole.
Southwire 30-m Demonstrator
Carrollton, GA USA

Cable Parameters:
• 12.4 kV
• 1.25 kA
• FC = 12 kA, 1 sec
• 30-m length

In past 12 mo.
• P3, phase-to-gnd fault on bus just outside termination
• Direct lightening strike in HTS yard

~30,000 hrs at 100% load
# AEP Project Partners

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<thead>
<tr>
<th>Partner</th>
<th>Area of Responsibility/Expertise</th>
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<tr>
<td>Southwire/nkte/Ultera</td>
<td>Cable design, manufacturing, termination design, installation, cryo system design, systems integration, O&amp;M, project management</td>
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<tr>
<td>AEP</td>
<td>Installation site engineering, site civil &amp; electrical construction, Commissioning, Monitoring, O&amp;M</td>
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<tr>
<td>ORNL</td>
<td>Cable research, termination research, testing, cryo design</td>
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<td>Praxair</td>
<td>Cryogenics system design, construction, operations &amp; service</td>
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<td>AMSC</td>
<td>HTS tape supplier</td>
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‘AEP Project’

U.S. Department of Energy
SPI Phase-III

- Utility Partner = American Electric Power
- Location = Bixby Substation, Columbus, OH
- Voltage = 13.2 kV
- Load Rating = $3.0 \, \text{kA}_{\text{rms}} \, \text{AC}$
- Fault Current Peak = $\sim 56 \, \text{kA}$
- Cable Design = Triax
- Other Features = Splice
  - Underground
  - Multiple 90° Bends
- Energize mid-2006
Tri-axial HTS cable prototype
Triax Cable + Termination Qualification Tests
The following has been **successfully** tested:

1. Single-phase DC current tests (measure critical current)
2. 3-phase DC currents at 3 kA for 12 hours (thermal stability)
3. Single-phase AC current to 3 kA (AC loss measurements)
4. 3-phase AC current to 3 kA (thermal stability for cable + terminations)
5. Single-phase rated voltage for 1 hour
6. 3-phase rated voltage for 1 hour
7. PD measurements at 15.6 kV, single-phase (per IEEE 48-1996 termination spec)
8. AC withstand to 39 kV, single-phase (per ICEA S-94-649-2000 cable spec)
9. BIL to 110 kV (per IEEE & ICEA specs)
Pulling & Mechanical Verifications

No damage or degradation to cable or cryostat from pulling

Cryostat Pulling

Cable Pulling
Cryogenic Cooling

Experience 1: Stirling coolers
2 years operation at AMK

Experience 2: Open system
4+ years operation at Carrollton

New: Q-drive + pulse tube
- low vibration
- low maintenance

Hybrid System
Vacuum + Pulse-Tubes
Worst-Case Fault Current Test
200 m HTS cable demo at AEP

- Bixby substation, Columbus, OH
- Development and manufacturing 2002-2005
- Installation/energize in the grid of American electric Power Co in 2006
- Operation 2006-2007 +

- ~200 meters in length
- Voltage = 13.2 kV
- Current = 3,000 Amps ACrms
- Power Rating = 69 MW
69 MVA power transfer at 13 kV (AEP-Bixby)

- 3x3 duct bank, 9 circuits
  - 6 inch ducts
  - 1000 kcmil copper
  - Copper conductors de-rated due to heating in adjacent ducts

OR

- One Triax HTS cable

Ultera™
A Southwire / nkt cables Joint Venture
Maximize use of Existing Rights-of-Way

• HTS cables offer high power density, 3,000+ Amp/phase
• Reduce voltage levels: “Transmission level power at distribution level voltages”
• Lower real estate cost by moving transformation substations to out-lying areas. Stations in dense urban areas can become smaller ‘breaker and switching only’ stations.

HTS Cables can help resolve:

• EMF from underground copper transmission cables
• Transformer installation & oil containment
• Thermal issues for HV copper cables – heat dissipation
• HV permitting issues with municipalities and regulators
• Real estate costs in dense urban areas
THANK YOU!