TECHNICAL BRIEF

OKLAHOMA GAS & ELECTRIC (OG&E)

FIVE TRIBES – PECAN CREEK 161 KV LINE

Company:	Oklahoma Gas & Electric (OG&E) is a regulated electric utility serving more than 800,000 retail customers in Oklahoma and western Arkansas, and a number of wholesale customers throughout the region. With about 6,800 megawatts of capacity, OG&E generates electricity from natural gas, coal and wind. OG&E's electric transmission and distribution systems span 30,000 square miles. Its parent company, OGE Energy Corp. (NYSE: OGE), is headquartered in Oklahoma City.
Network Upgrade Name:	Five Tribes - Pecan Creek 161 kV Ckt 1
Upgrade Description:	Reconductor 4.07-mile Five Tribes - Pecan Creek 161 kV line and increase electric current rating to 2000 A
Upgrade Specification:	All elements and conductor must have an emergency rating of at least 542 MVA
Upgrade Justification:	To address the overload of the Five Tribes - Pecan Creek 161 kV Ckt 1 line for the loss of Agency - Pecan Creek 161 kV Ckt 1 line
Location and Climate:	On average, Muskogee, Oklahoma has 227 sunny days per year with a July high temperature of approximately 94˚F and a January low temperature of 27˚F. The number of days per year with any measurable precipitation is 87. Oklahoma City had a mild summer in 2014 with an average temperature of 80˚F with mild winds.
Situation:	Five Tribes - Pecan Creek 161 kV Ckt 1 line was scheduled for an upgrade to increase capacity to 2000 A to meet the energy demands and reliability requirements of the growing economy. The existing line was built in 1954 on wood H-frame structures with 636 kcmil Grosbeak conductor. The structures displayed significant wear, so the line needed to be torn down and replaced with an entire new line.

Installation of Drake/ACSR/**E3X™** at Pecan Creek Substation.

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Challenge:	The 2000 A current rating required to support future capacity on the Five Tribes – Pecan Creek line exceeded the ampacity of OG&E's standard 795 kcmil Drake/ACSR. OG&E's next size in their standard conductor portfolio was a 1590 kcmil Lapwing/ACSR, which would more than adequately meet the future capacity. While new steel structures were required to replace the failing wood structures, upsizing to 1590 kcmil Lapwing/ACSR conductor would have required even taller and stronger structures and a significant increase to the overall project cost. This challenge provided an opportunity for OG&E to consider a new approach.
Solutions:	To identify a cost-effective alternative to upsizing the conductor, OG&E decided to move forward with the 795 kcmil Drake/ACSR design while simultaneously test piloting General Cable's new TransPowr® with **E3X™** Technology on the southern phase of the line. **TransPowr® with E3X™ Technology is a groundbreaking, heat-dissipating surface coated conductor that will transform power grid sustainability, reliability, efficiency and resilience. By lowering operating temperature, TransPowr® with E3X™ Technology reduces power losses and increases power carrying capacity, allowing greater efficiency and lower total system costs.** OG&E agreed to evaluate this new technology with the expectation that if a recordable lower operating temperature (up to 30%) were achieved, they would seriously consider using 795 kcmil Drake/ACSR/**E3X™** coated conductor on all phases to allow for increasing the electric current rating to 2000 A. The line was selected because it represented the best short-term opportunity to install several miles of both conductors for direct comparison and evaluation.

Five Tribes – Pecan Creek 161 kV Line Energized

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Pre-installation:	The new Five Tribes – Pecan Creek line is 4.07-miles of which 3 miles are straight terrain with no elevation changes. The line design consisted of steel H-frame towers with a single conductor bundle in flat horizontal phase arrangement. For validation purposes, Drake/ACSR with **E3X™** Technology was to be installed on the southern phase while standard Drake/ACSR was to be installed on the northern phase. Three reels containing 10,400 feet of Drake/ACSR with **E3X™** Technology produced at General Cable's Malvern, Arkansas manufacturing facility were used for this installation. General Cable shipped the conductor within standard bare transmission lead times. The addition of the **E3X™** Technology did not negatively impact the timeline nor the delivery schedule of the product. As is customary, the reels were inspected prior to installation, and no damage was found to either the surface coating or the conductor. It is important to note that the **E3X™** coating has been engineered to withstand transportation and storage handling without any special protection. The crew was introduced to the **E3X™** coated conductor, which has a non-reflective, matte gray appearance similar to a non-specular surface finish. There is absolutely no change to the interior of an overhead conductor with **E3X™** coating.
Installation:	New technologies often require changes in installation procedures. However, Drake/ACSR/**E3X™** can be installed without any modification to installation, termination or maintenance. Therefore no special equipment or techniques were used during installation. The tension method was used to install the conductor with the aid of a standard offset multi-groove bullwheel tensioner. Special Observation: During the installation process, some coating material was found on the bullwheel tensioner. This material was determined to be excess un-adhered coating material in the strand interstices of the conductor. There was no impact from the removal of this material on the conductor or the installation. For electrical connection purposes, the standard practice of using a steel wire brush on overhead conductors prior to electrical termination was used on the Drake/ACSR/**E3X™** to remove the coating. Wire brushing successfully removed the coating, and the light gray appearance of the coating served as an ideal visible indicator to ensure that the coating was completely removed. In contrast to standard electrical connection procedures, the only difference was a more deliberate wire brushing of the Drake/ACSR/**E3X™** conductor to ensure that the coating was removed. Both the standard Drake/ACSR and Drake/ACSR/**E3X™** conductors were sagged using the same method and criteria. The Drake/ACSR/**E3X™** conductor was sagged and clipped in following standard sagging procedures. Standard AFL Quick Compress® compression splices and dead-ends and standard MacLean Power System suspension clamps were used. There was no need to remove the coating for the mechanical connections as the **E3X™** coating is a thin layer that increases conductor weight by less than 0.4% within the manufacturing tolerances of the aluminum weight. During the mechanical connection process, the installed Drake/ACSR/**E3X™** conductor was visually inspected at the tower from a bucket truck and no issues were observed.

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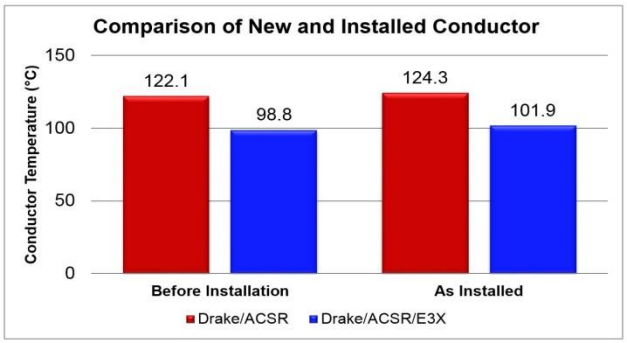
Testing:	Following installation, samples of the standard Drake/ACSR and Drake/ACSR/**E3X™** coated conductors that had passed through the tensioner and all stringing sheaves were collected at the very end of the line. These samples were sent to General Cable's Marshall Technology Center in Marshall, Texas to determine what impact, if any, the installation process had on the performance of the coated and uncoated conductors. To test the installed Drake/ACSR/**E3X™** coated conductors against the installed standard Drake/ACSR, the three coated conductors were placed in series with three standard conductors. The test loop was then subjected to electric current such that a temperature rise of 100°C over ambient was achieved during a 90-minute cycle.
Results:	The results showed a temperature reduction of 22.4°C for the Drake/ACSR/**E3X™** coated conductor compared to the Drake/ACSR. This was consistent with pre-installation testing on the coated conductor, which showed a reduction of 23.3°C over that of Drake/ACSR.  **With a successful installation, the line was energerized in November, 2013**
Ongoing Field Analysis:	The Drake/ACSR/**E3X™** conductor will remain in the air for an extended period of time to thoroughly evaluate the durability and environmental stability of the technology. Oklahoma had a mild summer in 2014. If temperatures and climate had been at their norm, results could have shown differently. Because the **E3X™** coating performs better as temperatures increase, situations with high load requirements or contingency loads will realize the best possible outcome from the coating. Once there is sufficient load, OG&E will monitor the temperature reductions of Drake/ACSR/**E3X™** coated conductor over time to determine performance. To validate that the lower operating temperature of the Drake/ACSR/**E3X™** coated conductor results in less thermal expansion and conductor sag, OG&E will be measuring the sag in comparison to Drake/ACSR over time.

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Conclusion:	General Cable's Drake/ACSR/**E3X™** coated conductor was installed without modification alongside standard conductor for performance evaluation in the 4.07-mile Five Tribes - Pecan Creek 161 kV line. This was to identify an alternative for increasing capacity to 2000 A to meet energy demands and reliability requirements without the significant cost associated with conductor upsizing. The **E3X™** coated conductor withstood transportation and installation, and did not require any special installation methods. Testing and validation will continue to demonstrate reduced operating temperature. Following this, OG&E can replace the other two phases with the Drake/ACSR/**E3X™** coated conductor to realize the best possible benefits from the coating and to allow the load of the line to increase. More importantly, OG&E can incorporate the **E3X™** new technology into their transmission network for increased power carrying capacity and design future lines with reduced power losses, achieving overall greater efficiency and lower total system costs.

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