345kV Transmission Line Thermal Uprating
Using Connector Shunts

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Transmission Project Background

• Early 2012 - Generator announced increasing capacity from 1,021 MW to 1,236 MW by January, 2014

• Solution - rebuild twenty-six (26) miles of 345kV on 2 circuits: Replace steel towers w/ 2-795kcmil ACSR Drake with New steel poles w/ 3-959.6kcmil ACSS Suwannee conductors

• Except - the time frame for this solution was not acceptable
Previous Line Uprating Decision Points

• In 2002 - the 345kV transmission lines were thermally uprated from 75°C /90°C (original design) to 90°C/120°C by modifying structures along the lines to raise the conductors

• In 2012 – determined that modifying structures to reconductor or temporarily uprate the line above 120°C was not possible
Higher Thermal Operating Option

• Operating solutions developed to rate lines at 120°C/120°C

• Normal load flows would rarely reach 120°C and a remedial action plan could mitigate a 4hr emergency of 120°C

• Conductor annealing calculations based on load profile showed negligible reduction in strength

• Concern – the 42 year old Connectors would be subjected to routinely higher normal load flows and a higher probability of reaching 4hr 120°C loadings under contingencies
ANSI C119.4 – 2011 Standard

- ANSI ASC C119.4 – 2011 - American National Standard for Electric Connectors—Connectors for Use Between Aluminum-to-Aluminum, and Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93°C and Copper-to-Copper Conductors Designed for Normal Operation at or Below 100°C

- Fact – The ANSI C119.4 Standard connector thermal heat cycle test protocols established in 1958 were developed for 75°C normal and 93°C emergency line operating conditions

- Fact – A connection will never be any better than the moment at which it is created. Once put in service it begins to deteriorate. The rate of deterioration is unpredictable.
Temperature Graphs of a Group of One Type of Tension Connector in the EPRI - 125°C Tests
Ways To Fix A Bad Connector

• Cut it out, install a section of conductor and 2 new connectors
• Cut it out and install a long repair connector
• Problem - Both of these methods usually require line outages and put the line in jeopardy during installation
• Solution - Leave the connector in service and install a shunt device to carry the current around the connector and provide mechanical strength for the connection
What Is A Connector Shunt?

- **Shunt (electrical)** - a device allowing electrical current to pass around a point in a circuit
Temperature Graphs of a Group of One Type of Connector Shunt in the EPRI - 180°C Tests

[Graph showing temperature trends over cycle number for different categories: Conductor Core, Conductor Surface, Shunt 1A, SP1, Shunt 1B, and Ambient.]
Decision Process to use Connector Shunts for Uprating the 345kV Transmission Lines

- Planned construction on other 345kV lines required that any work done on these circuits had to be completed by May 2013
- Flight inspection found a total of 88 tension and 168 jumper connectors along the 26miles of the two circuits
- The shunt devices had to be able to be installed by ground or air and with the lines energized
- The cost to install shunts on all connectors was estimated at approximately 2% of the estimated total rebuild cost = economical solution
- Opportunity to obtain an assessment of the condition of the connectors taking resistance measurements with a SensorLink® Radio Ohmstik Micro Ohmmeter prior to installing the connector shunts
Steps Required to Accomplish The Line Uprating

• Types of connector shunts had to be selected based on tension and deadend hardware configurations

• Size of tension and jumper connectors had to be measured to determine the correct dimensions for the shunts and get them manufactured

• Train linemen on the procedures to properly install the connector shunts

• Train linemen on the procedures to take connector resistance measurements with the Ohmstik® instrument

• Develop a connector identification and log scheme to record the resistance measurements
Installing A ClampStar® Jumper Connector Shunt
Why Not Use Infrared To Evaluate Connectors?
IR Would Tell Me The Connector Shunts Are Hot!
Taking Resistance Measurements with Ohmstik®
Resistance Ratios of All Connections
Resistance Ratios of Tension Connections
10 Years Old (Top) & 42 Years Old (Bottom)
Resistance Ratios of Jumper Connections
10 Years Old (Top) & 42 Years Old (Bottom)
Summary

• This project was CenterPoint Energy’s first field application of the Preformed® and the ClampStar® connector shunt devices

• The project was completed in the time required within budget

• The connectors on these 345kV lines represent only one type of connector and one type of line hardware configuration

• This project was used to learn how to make a field assessment of line connectors using the SensorLink® Radio Ohmstik Micro Ohmmeter

• The connector resistance measurements taken on these two 345kV circuits indicate that attention should be directed toward determining the electrical condition of connectors on other circuits