8th Anniversary
ELECTRIC® LIGHT & POWER

Double your transmission capacity without changing existing towers

General Cable

DENNIS DOSS III, P.E., GENERAL CABLE CORP.

Transmission line ratings are based on a maximum allowed operating temperature to limit conductor damage and maintain required clearances for public safety. Unfortunately, conductors can reach high operating temperatures when lines overload and we need power the most—peak demand during the summer. What if existing transmission lines could be upgraded to nearly double the line capacity with little or no changes to existing towers?

The high cost and nearly impossible environmental restrictions of constructing new lines have utilities looking for ways to stretch existing systems with minimal capital investment. One critical conductor property makes this a difficult situation. As the operating temperature of conductors increases, thermal expansion causes power lines to sag. This reduces the distance between the ground and energized conductors (vertical line clearance). The National Electric Safety Code

(NESC) mandates a specified vertical line clearance for the "maximum conductor temperature for which the line is designed to operate." This NESC requirement severely limits the current carrying capacity of existing lines. To solve this dilemma, technology and ingenuity gave rise to Aluminum Conductor Steel Supported/ Trapezoidal Wire (ACSS/TW).

ACSS/TW

The ACSS/TW, a natural evolution in conductor design, marries two proven overhead conductor technologies that have been available separately for over 25 years. ACSS/TW combines the benefits of high operating temperatures of ACSS and reduced diameter of TW. The result is significantly higher transmission capacity without increasing mechanical loads from larger conductors.

ACSS/TW is a composite concentric-lay-stranded cable with two or more layers of trapezoidal-shaped aluminum 1350-O wires surrounding steel strands that form the conductor's central core. The trapezoidal shape and soft aluminum (fully annealed "O" temper) provide performance advantages and cost savings by solving the problems of sag and limited current carrying capacity.

High temperature capability with less sag

Unlike conventional Aluminum Conductor Steel Reinforced (ACSR) conductors, the "O" temper of ACSS/TW causes most or all of the mechanical load to be transferred to the steel core. This means that ACSS/TW can operate continuously at more than twice the accepted temperature limit of ACSR conductors with significantly less sag. Operating at a higher temperature provides increased current carrying capacity to address higher electrical loads. Also, ACSS/TW is not affected by conductor aging, i.e. additional sag resulting from long-term creep of the aluminum.

Dennis Doss III, P.E., General Cable Corp.

More current carrying capacity with trapezoidal shaped strands

The trapezoidal shaped aluminum strands of ACSS/TW create a compact conductor with a smooth outer surface and smaller overall diameter. As compared to a conventional ACSR conductor with the same aluminum cross-sectional area, the ACSS/TW is approximately 10 percent smaller in diameter. The smaller diameter means lower ice and wind loads. In upgrade projects, this may allow higher initial tensions, which reduces final sag and permits higher operating temperatures—providing even more current carrying capacity with little or no structure modifications.

An alternate ACSS/TW design is available with an overall conductor diameter equivalent to that of a conventional ACSR conductor. The equal diameter option produces a 20 to 25 percent increase in the aluminum area. This increased area decreases the conductor AC resistance by 15 to 20 percent and significantly increases the current carrying capacity of the transmission line, providing energy saving advantages for consideration with new and upgrade projects.

Helps solve environmental headaches of new line construction

Because ACSS/TW sags significantly less than conventional conductors at high operating temperatures, there are numerous environment benefits to using ACSS/TW in new line construction. Lower sag enables reduced height and strength requirements for towers and poles, meaning they can be shorter or fewer in number. Also, the phase-to-phase conductor spacing may be reduced, which can lessen right-of-way requirements. In addition, tower height can be further reduced by stringing ACSS/TW at higher tensions to reduce sag.

Conventional aluminum conductors have a long history of use as transmission lines. But as power demands increase, environmental concerns grow and urban distribution systems age, a less-expensive, environmentally friendly solution has become essential for electric utilities to respond to recent trends. ACSS/TW's higher operating temperatures, reduced ice and wind loading, and increased conductor area nearly doubles the transmission capacity to address emergency electrical loading while reducing sag. Whether it's reconductoring existing lines with little or no changes to towers or constructing new lines with less environmental impact, ACSS/TW is a viable solution. ELP

Doss is director of engineering for General Cable Corp.'s (GCC) Utility Cable Group in Suffern, N.Y. He has 15 years experience as an engineer at an electric utility and 15 years experience as product engineer and now, director at GCC. He may be contacted at ddoss@generalcable.com

Primer on ACSS/TW overhead conductor

DENNIS DOSS III, P.E., GENERAL CABLE CORP.

The Aluminum Conductor Steel Supported (ACSS) bare overhead conductor was developed in the 1970s by the Electrical Division of Reynolds Metals (now part of General Cable Corp.). ACSS/TW (Trapezoidal ACSS) is an enhancement of the original product where the aluminum strands are pre-shaped into wedge-like shapes to fit tightly together and reduce empty spaces between strands. ACSS/TW conductors are used in upgrading existing transmission lines and in new construction projects to increase electrical load current and bolster system reliability. To date, thousands of miles of ACSS conductor have been installed throughout North America and ACSS/TW is gaining ground in the overhead conductor market.

EL&P invited Dennis Doss, director of engineering at General Cable for Utility Cable products, to provide this month's expert answers to commonly asked questions about ACSS/TW.

What is the history behind the ACSS/TW Product?

In 1974, Reynolds Metals patented the ACSS conductor design. Its original name was Steel Supported Aluminum Conductor (SSAC). The original patents have expired and the product is now known as ACSS. There are currently three major North American conductor manufacturers that offer ACSS products both round wire and trapezoidal wire (TW).

The TW enhancement to ACSS was transferred from existing technology developed for ACSR (Aluminum Conductor Steel Reinforced) and AAC (All Aluminum Conductor) TW conductors. ACSS/TW is typically manufactured to meet the aluminum cross-sectional area of a standard round conductor, but allows the overall diameter to be reduced by approximately 10 percent. ACSS/TW can also be manufactured to meet the existing diameter of a standard conductor, incorporating 20 percent to 25 percent more aluminum cross-sectional area.

What does ACSS or ACSS/TW look like?

From the outside, ACSS and ACSS/TW conductors look like traditional ACSR. All are manufactured with steel cores and aluminum outer strands. The key difference is that the ACSR aluminum is made from hard drawn aluminum, while ACSS uses soft aluminum (i.e. annealed, or "O" temper). In the ACSS/TW trapezoidal conductor, the aluminum strands are not round but trapezoidal shaped.

What is so special about using annealed aluminum strands?

Both ACSR and ACSS conductors are made from two different metals—aluminum and steel. Consequently, the composite conductor behavior is determined by the combined electrical and mechanical properties of the two materials that make up the conductor. Although ACSR and ACSS are made with 1350 alloy aluminum, their electrical and mechanical properties are very different.

Electrically, the conductivity of hard drawn aluminum in ACSR is 61.2 percent; whereas, soft aluminum has a conductivity of 63 percent relative to copper (100 percent). This means that the soft aluminum in ACSS is more efficient at transporting power. Mechanically, the tensile strength (resistance to breaking) of hard drawn aluminum in ACSR is approximately three times that of soft aluminum. This means that the aluminum in ACSS conductor contributes much less to the overall strength, and the composite conductor behaves more like steel.

What are the consequences of elevated conductor temperature on ACSR?

When ACSR conductors are operated at temperatures in excess of approximately 93º C, the aluminum starts to anneal. The annealing weakens the conductor and can potentially cause the conductor to break under high wind or ice conditions. To prevent this from happening, utilities generally limit conductor temperatures to 75º C for an ACSR conductor.

ACSS/TW and ACSS conductors are manufactured using soft (annealed) aluminum, where operation at higher temperatures has no further effect on the aluminum's tensile strength. Compared to regular ACSR, predictable installation parameters can be calculated for the ACSS/TW conductors to take into consideration the sag and tension performance at the higher temperatures.

What is the temperature rating of ACSS?

The original temperature limit of 200º C has been in existence for almost 30 years and has proven itself. This was based on a 245º C temperature limit established by steel core manufacturers for the galvanized coating of the steel. Operation of the ACSS product at higher temperature (e.g. 250º C) warrants the use of an enhanced type of galvanizing, which provides more durable high temperature endurance performance (Misch Metal—zinc/aluminum alloy coating). Another option for high temperatures is aluminum clad steel.

How high can the operating temperature realistically go?

Theoretically, the 250º C rating would provide the ability to carry more power through transmission lines. However, the question must be asked, "Is it wise to operate an electrical system at that high of a temperature?"

The amount of electrical current passing through the conductor combined with environmental conditions determines the operating temperature of the conductor. Electrical current causes the following: a) The higher the current, the hotter the conductor and the greater the power losses. Ideally, lines are designed to minimize these power losses and keep normal day-to-day power loads well below the 200º C operating temperature limit. b) The hotter the conductor, the more it will sag and to compensate, the use of larger and/or stronger structures would be required. c) Electrical current also passes through the conductor joints (splices) and end fittings (dead ends), forming "weak links" that can mechanically and electrically fail because of overheating. Conductor supports and insulators also become more susceptible to failure. To sum things up, pushing the temperature limit to 250º C remains an unproven condition.

What are the best applications for use of the ACSS and ACSS/TW products?

System reliability issues push the need for the use of ACSS. Utilities are being pressured to demonstrate system reliability. The ACSS/TW conductor could enable a tremendous emergency load carrying capability that the utility could call upon when needed.

Cyclic Loads and Peak Demand can be accommodated using ACSS/TW because it can operate at temperatures higher than ACSR. ACSS/TW enables utilities to plan for future situations of increased power requirements because ACSS/TW has power carrying capacity already built into the system.

Utilities can also turn to ACSS products in situations where they need additional power capacity along existing right-of-ways, but are facing the environmental challenges of building new lines. The ACSS/TW reconductoring option may be the only solution available to upgrade lines with minimal changes along existing routes. ELP

Doss is director of engineering for General Cable Corp.'s (GCC) Utility Cable Group in Suffern, N.Y. He has 15 years experience as an engineer at an electric utility and 15 years experience as product engineer and now, director at GCC. He may be contacted at ddoss@generalcable.com.