EPRI

Advanced Conductors

INTRODUCTION

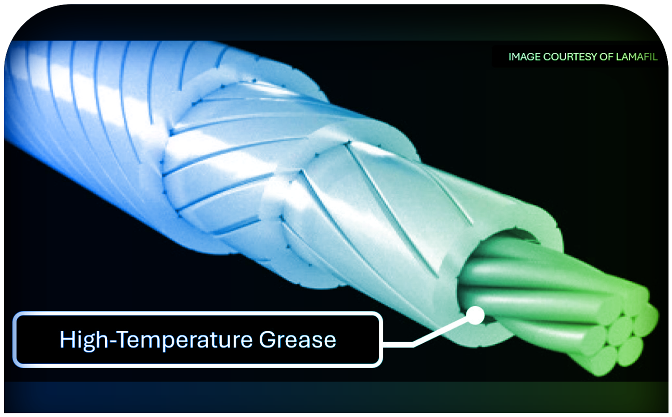
The term advanced conductors refers to conductors designed to operate at high temperatures (typically above 150°C). In recent years, conductor manufacturers have begun to produce new overhead line conductors that can operate at these higher temperatures while respecting critical safety considerations, such as managing sag to reduce electrical clearances to ground and other objects.

Some of these conductors are made of traditional materials such as aluminum and steel, while others use metal matrix or organic matrix (carbon) cores. Organic matrix core technology incorporates new materials that have not previously been used for overhead line conductors.

Advanced conductors can increase the capacity of the transmission system by:

- **Reconductoring:** This involves upgrading the existing transmission system's transfer capacity by reconductoring selected network lines with conductors capable of transmitting greater electrical capacity. This effectively increases the power transfer capacity of the existing transmission system and increases the use of existing rights of way.
- **Building new transmission lines:** Advanced conductors can be used when building new transmission lines when high power transfer capacity is needed.

Advanced conductors directly benefit alternating current (ac) lines that are thermally limited by the conductor. Using advanced conductors on these short-distance (less than 50 miles) lines could increase the current-carrying capacity by 5% to 50%.



Advanced conductors may include nonproprietary conductors—on which patents have expired, often making them more cost-effective alternatives—and proprietary conductors, which generally have a cost premium. Nonproprietary conductors are typically standard conductors with the addition of different alloys enabling higher temperature operation; e.g., zirconium may be added to an aluminum (Al) alloy to provide resistance against annealing, at the expense of conductivity. An example is gap-type GZTASCR conductor (shown in the figure) that uses a Zirconium aluminum alloy decoupled from the steel conductor core, which is coated in high-temperature grease.

Proprietary advanced conductors incorporate some or all of the following aspects that enable increased power flow:

- The ability of conductor materials to accommodate temperature increases
- Reduced thermal expansion characteristics
- Reduced conductor weight and installed tension (in carbon core and metallic matrix core conductors)

STATE OF THE TECHNOLOGY

Although these conductors have been on the market for several years, uncertainty remains on some specifications for procurement, installation, long-term performance (thermal degradation and mechanical—for example, ice loading), and inspection methods for the conductors and associated hardware.

Deployments of these conductors over the last 15 years have provided significant learnings. One such learning is that most failures of advanced conductors have been attributed to improper installation. Further research on installation, as well as long-term performance (thermal degradation and mechanical—for example, ice loading), inspection, and assessment after a critical mass of conductors is deployed can de-risk investments.

Some of the uncertainty surrounding the use of advanced conductors can be attributed to the lack of specifications during procurement. EPRI has developed guidelines to aid utilities in preparing these specifications, including tests and standards requirements. These specification guidelines have recently been made freely available to the industry.

The long-term thermal and mechanical performance of these advanced conductors is not fully understood. As more of the advanced conductors are deployed, valuable service experience is being obtained. Key topics that must be better understood include vibration and the ice-loading performance of these conductors.

As these conductors age in the field, the need for core inspection and condition assessment increases. Although several different technologies and methods for inspecting the core of steel conductors exist, it is difficult to determine the condition of nonsteel core advanced conductors.

Despite being significantly more expensive (typically 2.5 to 5 times the cost of equivalent aluminum conductor steel reinforced [ACSR] conductors), most proprietary advanced conductor options offer capacity increases that would otherwise not be achievable with conventional or nonproprietary conductors without significant modifications to the structures—or even a possible rebuild.

Reconductoring an existing line with new advanced conductors has mostly been performed when rebuilding the line is prohibitive from a network constraint perspective. In some cases, the cost of proprietary advanced conductor options may be comparable with the cost of building a new line; however, it can avoid costs related to rebuilding or reinforcing structures. Some of the advanced conductors available include those in Table 1.

Other advanced conductor technology providers include the following:

- LS Cable
- De Angeli Prodotti
- NEXANS
- Tratos Cavi
- La Farga
- J-Power

Table 1. *Available advanced conductors*

NAME	DESCRIPTION	TECHNOLOGY PROVIDER
Aluminum conductor composite reinforced (ACCR)	• Metal matrix stranded core • Aluminum-zirconium outer strands	3M
Aluminum conductor composite core (ACCC)	• Mono carbon core enclosed in glass fiber • Fully annealed aluminum or aluminum-zirconium outer strands	CTC Global
Aluminum conductor steel supported (ACSS)	• Galvanized or mischmetal coated steel stranded core • Fully annealed aluminum outer strands	Various
C7	• Stranded carbon core • Fully annealed aluminum or aluminum-zirconium outer strands	Southwire
TS	• Mono carbon core encapsulated in an aluminum sheath • Fully annealed aluminum outer strands	TS Conductor

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO SCALE AND GROW

EPRI is continuing research on advanced conductors, with a focus on the activities that de-risk and optimize the use of advanced conductors:

- Improved installation procedures for newer generation conductors to prevent installation damage
- Inspection and assessment of conductors, including determination of carbon core integrity, through the development of inspection and maintenance procedures
- Safe installation tensions for aluminum conductor steel supported (ACSS) conductors, which have improved and yet unleveraged self-damping characteristics
- Incorporation of testing procedures and methods into standards, such as incorporation of EPRI's thermal mechanical test protocol into ANSI C119.7, "Connectors for Use Between Aluminum-to-Aluminum Conductors Designed for Normal Operation Above 93°C"
- Continued laboratory and field evaluations, with technology providers as well as national laboratories to increase understanding of icing, vibration, and other unknowns

EPRI's laboratory testing includes field sites where advanced conductors are being monitored with advanced sensors to assess thermal, mechanical (ice loading), and vibration performance. The Charlotte, North Carolina laboratory test site facilitates accelerated aging thermal mechanical testing, conductor system tensile testing, vibration testing, and strand and core tensile testing.

Two field test sites are scheduled for installation in 2024 that will complement in-field monitoring of existing installations. A new monitoring project is being planned for carbon core installation in July 2024 in the northwestern United States, an environment known for icing. Two monitoring sites will continuously measure the tension, vibration, and galloping of the conductors as well as the local weather conditions.

Through EPRI's GET SET Initiative, EPRI has made public a specification that utilities may use when procuring advanced conductors. This specification, developed with member utilities and engagement with technology providers, includes new tests that utilities can use to procure advanced conductors and connectors based on the results of accelerated aging tests that EPRI has conducted for more than a decade.

Plans are in place to release a report summarizing utility use cases where advanced conductors have been implemented as well as a report summarizing more than a decade of test results.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

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