- The reduced conductor diameter for a given ac resistance yields reduced wind and ice loading, thereby reducing structural loading.

1.6.4 High Temperature Conductors

The need to move larger quantities of power through existing right-of-ways (ROW) has led to increased interest in high temperature conductors. These conductors fall into a category known as High Temperature, Low Sag (HTLS) conductors. In addition to ACSS, which has extensive usage, several new types of conductors are being marketed. With the exception of ACSS and ACSS/TW, all HTLS conductors require special installation procedures and hardware.

Aluminum Conductor, Steel-Supported (ACSS)

ACSS conductor has been in use since the early 1970's. Originally known as SSAC[22], ACSS was designed to operate at higher temperatures than ACSR, increasing current carrying capacity at reduced sags. Since construction costs were low and ROW access easily obtainable, ACSS did not have a large impact on the design of transmission lines when it was originally introduced. As the transmission line environment has changed, the advantages of ACSS can now be fully utilized in transmission line design.

ACSS consists of a core composed of coated steel wires surrounded by one or more layers of fully annealed, 1350-O aluminum round wires. Core wire coatings used include galvanized zinc, aluminum coated, aluminum clad and Zinc-5% Aluminum-Mischmetal Alloy. There are three strength ratings available for the steel core wire: standard, high and ultra high (Southwire HS285). Unlike an ACSR conductor, which receives a significant portion of its strength rating from its 1350-H19 aluminum wires, only a very small portion of an ACSS conductor's strength comes from its 1350-O aluminum wires.

This has two significant implications for ACSS: an ACSS conductor looses only minimal strength when operated at temperatures above 94°C (the onset temperature for annealing of aluminum wires); and the sag response for an ACSS conductor is determined primarily by the sag response of the steel core. This means that the rate of change in sag with temperature for an ACSS conductor is much less than that of an equivalent area ACSR conductor.

ACSS is available in three constructions: round wire, area equivalent Trapwire and diameter equivalent Trapwire. Some advantages of ACSS are:

- ACSS has a conductivity of 63% IACS or better due to the aluminum strands being "dead-soft" (fully annealed). This can translate to higher ratings and lower operating costs.

- Since the aluminum strands are dead-soft, the conductor may be operated at temperatures in excess of 250°C without loss of strength.

- After the conductor has been stressed, the tension in the aluminum strands is low, providing excellent self-damping. This allows the conductor to be installed at high unloaded tension levels without the need for dampers.

- When operated above 180°C, testing has shown that the internal temperature of the conductor can cause standard zinc coatings to degrade. Therefore, it is recommended that either an aluminum clad or Zinc-5% Aluminum-Mischmetal Alloy coated core be used.

- Reconductoring of existing lines with ACSS and ACSS/TW conductors can yield a substantial increase in current carrying capacity while maintaining existing clearance limits.

- Construction of new lines with ACSS has less environmental impact by reducing the number and/or height of required structures.

- Because of its lower thermal elongation, ACSS exhibits less sag with increasing temperature than ACSR.

As discussed in more detail in Chapter 7, these characteristics have made ACSS an attractive choice, both for reconductoring existing transmission and distribution lines and for use in new lines. ACSS is especially suitable for new line and uprating applications where high load currents are the result of occasional emergency and contingency situations.

Aluminum-Zirconium Alloy Conductor, Steel-Reinforced (TACSR)

This family of conductors is constructed using thermal-resistant aluminum-zirconium (Al-Zr) alloy wires stranded over a reinforcing steel core. There are several Al-Zr alloys available, each having a different temperature rating as summarized in Table 1-17. All types of these conductors have traditional concentric round wire strandings similar to ACSR.

TABLE 1-17
TEMPERATURE RATINGS OF
ALUMINUM-ZIRCONIUM ALLOYS

Symbol	Max. Temperature		Conductivity
	Continuous °C	Emergency °C	% IACS
TACSR	150	180	60
UTACSR	200	230	57
ZTACSR	210	240	60
XTACSR	230	310	58

Thermal-Resistant Aluminum Conductor Invar Reinforced (TACIR)

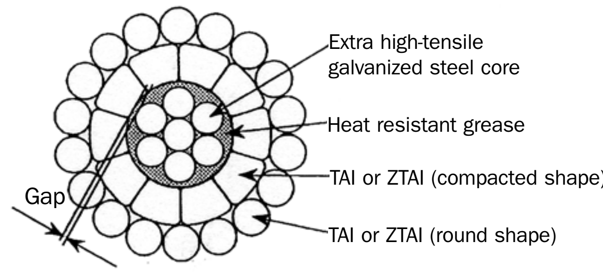
TACIR conductors are similar to the TACSR family of conductors except the standard steel core is replaced with a special iron-nickel alloy ("INVAR") steel core. Invar is typically aluminum clad to provide corrosion resistance at elevated operating temperatures. This core material has a smaller coefficient of thermal expansion and lower tensile strength than galvanized steel. Conventional galvanized steel core wire has a tensile strength of 170 to 190 ksi. Invar steel wires have a 15-20% lower tensile strength but also have a much lower coefficient of thermal expansion. The thermal expansion coefficient of conventional steel is 11.5×10^{-6} /°C whereas the thermal coefficient of Invar steel is only 2.8×10^{-6} /°C.

These conductor are similarly designated TACIR, UTACIR, etc. Both TACSR and TACIR type conductors have been used mainly in Asia to date.

Gap-Type Thermal-Resistant ACSR (GTACSR)

Gap-type ACSR conductors are constructed with a gap between the galvanized steel core and innermost shaped aluminum layer, as shown in Figure 1-13. The gap is filled with a heat resistant grease to reduce friction between the steel core and aluminum and to prevent water penetration. This allows the conductor to be tensioned by gripping the galvanized steel core only. The conductor is then able to take full advantage of the lower thermal elongation properties of steel.

FIGURE 1-13
GAP-TYPE ACSR (GTACSR)



Gap-type conductors employ the same thermal-resistant aluminum-zirconium (Al-Zr) alloy wires used in TACIR conductors and are designated GTACSR, G(Z)TACSR, etc. Gap-type conductors have seen only limited usage in the United States to date.

Aluminum Conductor Composite Reinforced (ACCR)

ACCR conductors are constructed with Al-Zr alloy wires (round or trapezoidal) over a reinforcing core consisting of stranded ceramic filaments. Each filament consists of ceramic fibers encased in an aluminum matrix. The composite core has a lower thermal elongation and equal or greater strength than galvanized steel. This conductor is typically rated 210°C to 240°C. Currently, 3M is the only manufacturer of this type of composite core. The 3M ACCR conductors have had extensive laboratory testing, but limited service application to date.

FIGURE 1-14
ALUMINUM CONDUCTOR COMPOSITE REINFORCED
(ACCR)

Courtesy of 3M.

Aluminum Conductor Composite Core (ACCC)

ACCC conductors have a core consisting of polymer-bound carbon-fibers encased in a fiberglass tube. This core may be described better as a "rod" than a single strand core. ACCC is typically constructed using trapezoidal shaped, fully annealed 1350-O aluminum wires over a single "strand" (rod) composite core, as seen in Figure 1-15, and is typically rated at 200°C.

ACCC was developed by Composite Technology Corporation (CTC) and is relatively new to the utility market. It has seen limited service application to date.

FIGURE 1-15
ALUMINUM CONDUCTOR
COMPOSITE CORE (ACCC)

Courtesy of CTC.