Endurance Tests

ACCR Celanese (2015)

This section describes testing performed in 2015 on T13 aluminum conductor, composite reinforced trapezoidal wire conductor with a carbon fiber thermoplastic composite core (ACCR/TW/C^7). This 995 kcmil conductor has an equivalent diameter as ACSR "Drake" conductor.

It consists of a core of seven carbon fiber thermoplastic composite (Celstran CFR-TP) strands covered by two layers of twenty trapezoidal-shaped aluminum-zirconium (zirconium-treated or ZT) alloy wires. The carbon fiber thermoplastic composite core consists of heat-resistant PPS polymer matrix enclosed in high-performance PEEK capping layer. The organic composite core is manufactured by Celanese and the conductor is stranded by Southwire.

The outside diameter of the conductor is 1.108 inches, and its rated breaking strength (RBS) is 41,400 lbs. The diameter of each individual core strand is 0.1370 inches, and the overall core diameter is 0.4110 inches. The continuous rating temperature of T13 ZTACCR/TW/C^7 conductor is defined in the technical data sheet as 180 °C.

Results

The Celanese ACCR C^7-TW test conductor passed 500 thermo-mechanical cycles and underwent the breaking load test afterwards.

The following observation was made with regards to the breaking load test:

1. The dummy conductor breaking load was at 39,291 lb. or 122.4% of conductor's RBS.
2. This is very close to what was measured for tensioned test conductor, 39,842 lb. or 124.1% of conductor's RBS.

Later iterations of the conductor data sheet showed that the RBS of the Celanese ACCR C^7-TW conductor was significantly increased, first to 45,800 lbs and then to 41,400. If these RBS values are correct then the percentage residual strength of the conductor would be much lower than originally calculated. This is shown in Table 3-6 below.

Table 3-6. Celanese ACCR C^7-TW Residual Strength Percentages

	Residual percentage strength based on 32,100 RBS	Residual percentage strength based on 45,800 RBS	Residual percentage strength based on 41,400 RBS
Return (dummy) conductor	122.4	87.16	96.43
Test conductor	124.1	86.99	96.2

All compression dead-ends were installed as per manufacturer's instruction applying high temperature inhibiting compound, except for one (1) dead-end installed on the Celanese ACCR C^7-TW dummy conductor. The purpose of this installation was to compare the performance of dead-ends installed with and without inhibiting compound. The temperature measurements at the end of each cycle for the dead-end connectors installed on the Celanese ACCR C^7-TW dummy conductor showed good thermal stability during the five hundred (500) cycles. The South dead-end (ungreased) connector showed temperature measurements of ~10 °C higher than the North dead-end (greased) connector. The measurements of the North dead-end installed on the test conductor show temperatures ~2-5 °C higher than the North dead-end installed on the dummy conductor. This slightly higher temperature is likely due to the tension effect on the test conductor.

Figure 3-11. Celanese ACCR C^7-TW Test Conductor after the Breaking Load Test

The elevated temperature Thermo-Mechanical Cycling Test was performed to demonstrate the performance of the ACCR/TW/C^7 Conductor with Celstran CFR-TP core when exposed to combined thermal and mechanical stresses. The Celanese ACCR C^7-TW dummy conductor, which was not tensioned during the test and only exposed to thermal cycling, had almost the same remaining mechanical strength (122.4% RTS) than the Celanese ACCR C^7-TW tensioned test conductor (which broke at 124.1% RTS). With only two (2) data points, the results suggest that the combined loading of thermomechanical cycling and the high-tension loads (70% RTS)

may not decrease the ACCR/TW/C^7 Conductor's remaining tensile strength (test conductor after the breaking load test is shown in Figure 3-13).

ACCS Celanese (2016)

This section describes testing performed in 2016 on T13 aluminum conductor, composite supported trapezoidal wire conductor with a carbon fiber thermoplastic composite core (ACCS/TW/C^7). This 995 kcmil conductor has an equivalent diameter as ACSR "Drake" conductor.

It consists of a core of seven carbon fiber thermoplastic composite (Celstran® CFR-TP) strands covered by twenty trapezoidal-shaped 1350-O aluminum wires stranded in two layers. The carbon fiber thermoplastic composite core consists of heat-resistant polyphenylene sulfide (PPS) polymer matrix enclosed in high-performance polyetheretherketone (PEEK) capping layer. The organic composite core was manufactured by Celanese and the conductor was stranded by Southwire.

The outside diameter of the Celanese ACCS C^7-TW conductor is 1.108 inches, and its rated breaking strength (RBS) is 35,800 lbs. The diameter of the individual core strands is 0.136 inches, and the overall core diameter is 0.408 inches. The continuous rating temperature of T13 ACCS/TW/C^7 conductor is defined in the technical data sheet as 180 °C.

Results

The following observations were made with regards to the breaking load tests on the North and South halves of the Celanese ACCS C^7-TW dummy assembly:

1. The North half of the dummy assembly experienced a pull-out failure at 31,232 lb. or 87.2% of conductor's RBS.
2. The South half of the dummy assembly experienced a pull-out failure at 33,656 lb. or 94.0% of conductor's RBS.
3. Both samples failed inside their respective compression dead-ends.
4. The appearance of both failures was like that experienced by the test assembly (i.e., "pull-out" failure exhibiting ductile fracture of aluminum strands and intact composite core strands).