DC Resistance for 824.0 kcmil ACCR Overhead Conductor

NEETRAC Project: 24-151

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1.0 BACKGROUND

Resistance is an important property for a conductor because it determines the energy loss (called line loss) caused by heating as the current flows in the conductor. Lower resistance means lower line loss. Data tables for conductors list both AC resistance values and DC resistance values. Both are computed based on the conductor nominal dimension and the maximum allowable volume resistivity of the metal, typically aluminum or copper. The computation includes stranding increments based on the increased length of the helically wound strands.

AC resistance is difficult to measure, and highly specialized equipment is required. DC resistance is easily measured by passing a known DC current through the conductor, and measuring the voltage drop over a defined length, 20 ft in the case of the NEETRAC measurements. The DC resistance is defined as the ratio of the voltage to the current (V/I). Per industry practice, the measured DC resistance is corrected to a 20 °C reference temperature using industry standard resistance temperature coefficients.

2.0 TEST SAMPLE

A test sample was removed from a reel provided by INL circa January 2025. The designation on the reel identified the conductor as 824.0 kcmil ACCR. Table 1 shows the resistance and ampacity values per the manufacturer.

Table 1: Resistance and Ampacity per Manufacturer's Literature

Conductor Temperature		RESISTANCE (Ω/mi)		AMPACITY			
°C	°F	DC	60 Hz AC	Sun No Wind	No Sun No Wind	Sun Wind	No Sun Wind
20.0	68.0	0.1066					
25.0	77.0	0.1087	0.1102	****	****	****	****
50.0	122.0	0.1194	0.1207	****	327	180	478
75.0	167.0	0.1300	0.1313	502	658	756	867
90.0	194.0	0.1364	0.1376	681	797	931	1019
100.0	212.0	0.1407	0.1418	777	878	1027	1105
125.0	257.0	0.1514	0.1524	976	1052	1225	1286
150.0	302.0	0.1620	0.1630	1138	1200	1384	1436
175.0	347.0	0.1727	0.1736	1278	1330	1521	1565
200.0	392.0	0.1834	0.1842	1404	1449	1643	1681
210.0	410.0	0.1876	0.1885	1451	1493	1688	1725
225.0	437.0	0.1940	0.1949	1519	1559	1754	1789
240.0	464.0	0.2004	0.2012	1585	1622	1818	1850

3.0 PROCEDURE

A bolted clamp (see Figure 1) was applied at each end of the 24-ft sample before cutting the sample from the reel. This preserves the as-manufactured position of each strand and each layer. All strands, including the aluminum matrix core strands, were puddle-welded into an aluminum plate that ensures balanced current flow to each strand including the core strands. A fabric sling was fitted to the bolted clamp at each end of the sample, and used to apply a nominal 200 lb tension to straighten the sample. Figure 1 shows the tensioning strap, bolted clamp, and welded current terminal, typical at each end of the sample.

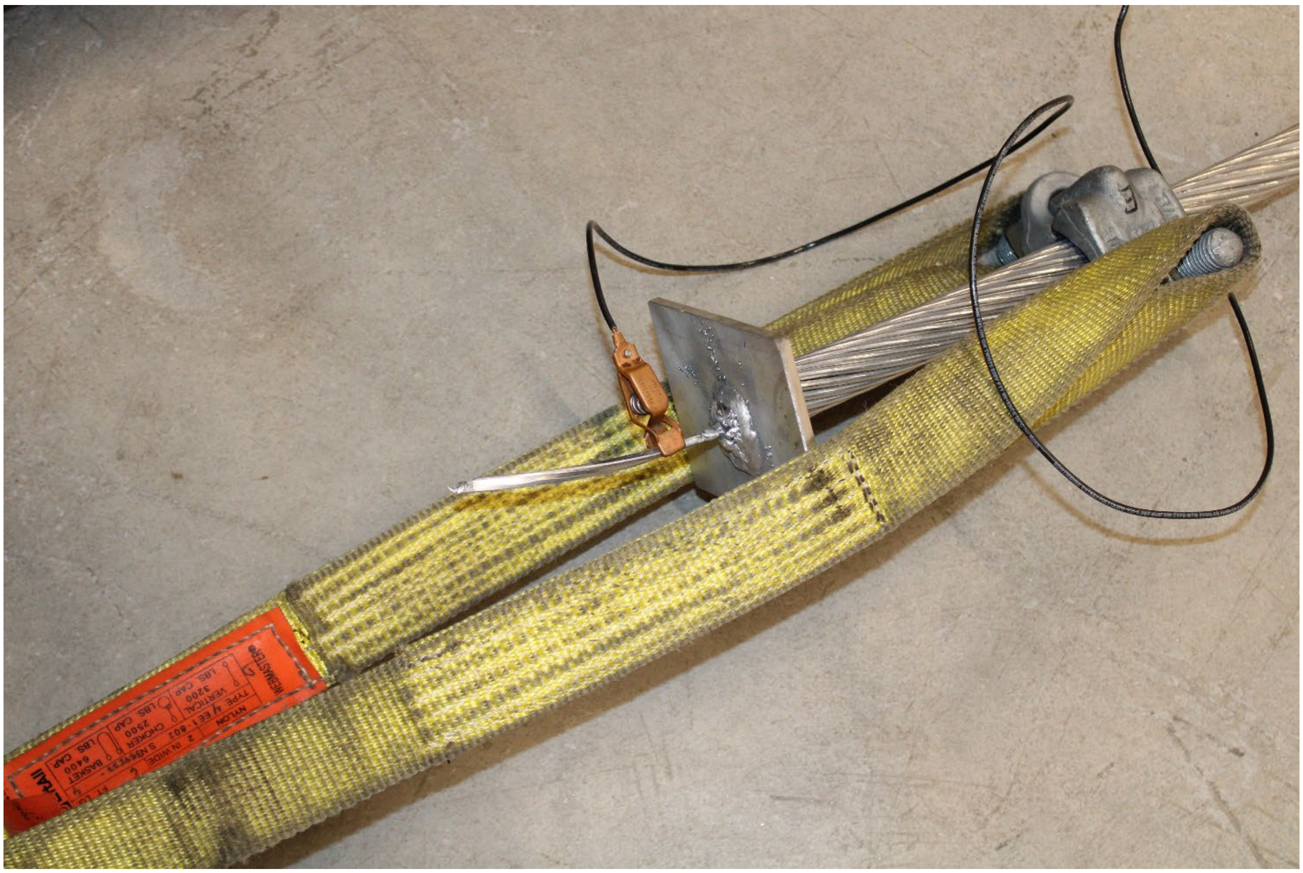

Figure 1: Puddle-Welded Equalizer and Bolted Clamp, Typical Each End

Voltage terminals were applied to the conductor free span to define the exact length for the resistance measurement. A length of #20 AWG solid copper wire is wrapped around the conductor, and the ends twisted to form a tight garter around the conductor. Assuming balanced current distribution among the conductor strands and layers, the voltage drop measured at the surface is a valid measure of the conductor's DC resistance.

Figure 2 shows the voltage terminal defining one end of the gage section.

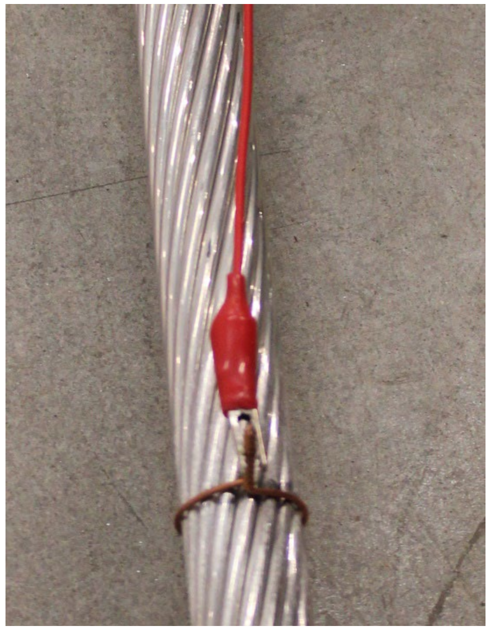

Figure 2: Voltage Terminal (typical two locations)

The sample is in conditioned lab space overnight to ensure it is in thermal equilibrium. A type T thermocouple was inserted between two strands of the outer layer to provide the temperature needed to correct for the temperature dependency of the volume resistivity. Per industry practice, the measured resistance was converted to the equivalent resistance at conductor temperature of 20.0 °C. The average of the “before reading” and “after” reading temperature was used for the resistance correction. Temperature stability is confirmed by no change or 0.1 °C change in temperature during any single resistance measurement.

DC resistance in the conductor was determined by reference to a standard resistor. Using the same voltmeter to measure both the sample voltage and the resistor voltage cancels any measurement errors, and results in reliable resistance measurements.

The data was obtained by creating a current loop in the following sequence:

1. Positive terminal of the DC power supply
2. Reference resistor current terminal 1
3. Reference resistor current terminal 2
4. Sample equalizer 1
5. Sample equalizer 2
6. Negative terminal of the DC power supply

Figure 3 shows the benchtop arrangement of the test equipment. The DMM leads were moved manually to measure the sample voltage drop and the reference resistor voltage drop. Small differences in the measured resistance values are believed to be caused by unequal settling time for the DMM at the microvolt measurement scale.

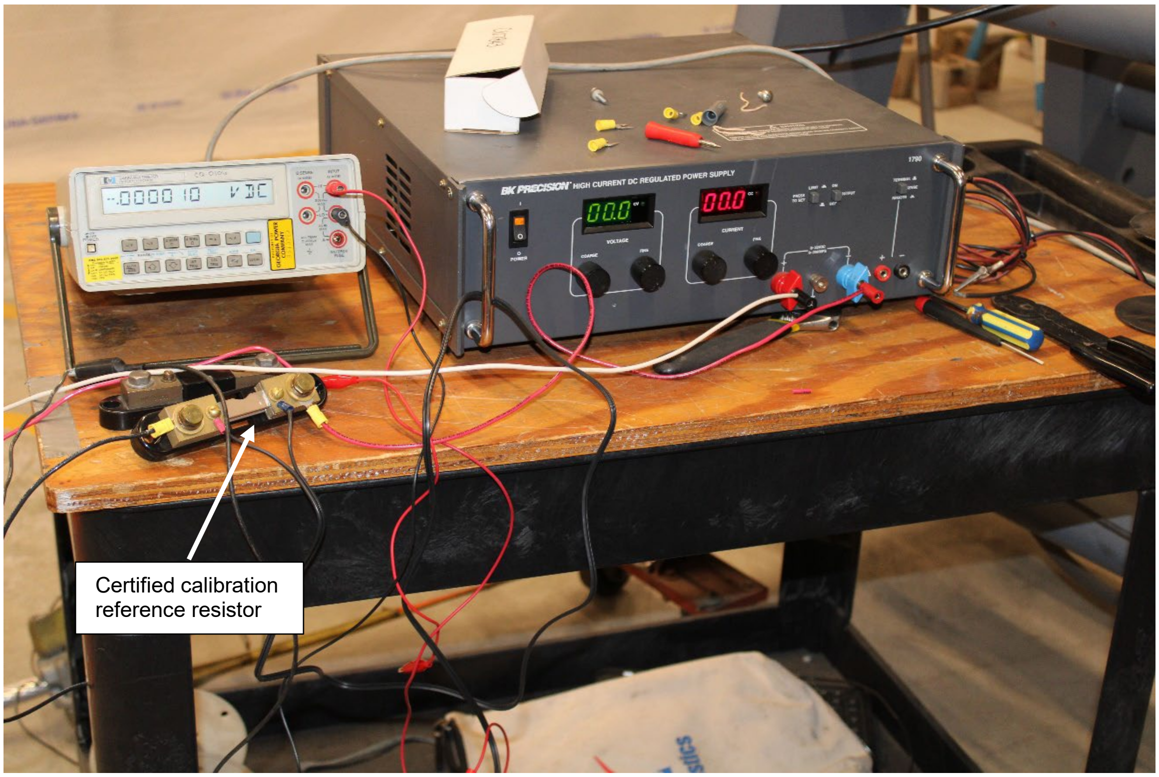

Figure 3: Test Equipment

4.0 RESULTS

Table 2 shows the raw voltage readings and the process used to determine the resistance per mile at the 20 °C reference temperature. Temperature corrections used a resistance temperature coefficient of 0.0040 per ASTM 941 “Standard Specification for Heat Resistant Aluminum-Zirconium Alloy Wire for Electrical Purposes”.

Table 2: Voltage Measurements and Conversion Process

Current Direction	Shunt Voltage Vs (VDC)	Loop Current (Vs/Rs) (A)	Sample Voltage (VDC)	Sample Resistance (V/I) (µΩ)	Sample Temp Before (°C)	Sample Temp After (°C)	Sample Resistance @ 20 °C (µΩ)	DC Resistance @ 20 °C (Ω/mi)
+	0.004769	9.5155	0.003858	405.44	20.5	20.6	404.55	0.1069
-	0.004756	9.4895	0.003816	402.13	20.6	20.7	401.08	0.1059
+	0.004755	9.4875	0.003869	407.80	20.7	20.6	406.74	0.1074
-	0.004743	9.4636	0.003857	407.56	20.6	20.7	406.50	0.1074
+	0.004788	9.5534	0.003859	403.94	20.7	20.7	402.81	0.1064
Shunt Resistance Rs:	501.183403	µΩ	Gage Section:	19.990	ft	Res. Temp Cx:	0.0040	

The average of the five (5) resistance measurements is 0.1068 Ω/mi with a standard deviation of 0.00064 Ω/mi. The ± three-sigma confidence interval is 0.1087 Ω/mi to 0.1049 Ω/mi.

5.0 DISCUSSION / CONCLUSIONS

ASTM B978, “Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum Matrix Composite Reinforced (ACAMCR), Formerly ACCR” does not provide resistance values, but states that DC resistance may be computed using volume resistivity values provided in the Standard. It further states that the values are typical and not maximum. Per the manufacturer’s chart shown as Table 1, the nominal DC resistance at 20 °C is 0.1066 Ω/mi, which is in good agreement with the 0.1068 Ω/mi valued determined by test.

6.0 EQUIPMENT

BK Precision model 1790 regulated DC current supply

Hewlett Packard 3468A Digital Multimeter, calibration control # CQ0106

OMEGA HH378 Thermocouple Reader, calibration control # CQ6766

Impro Calibration Reference Resistor, 501.183403 µΩ, calibration control number CN7843