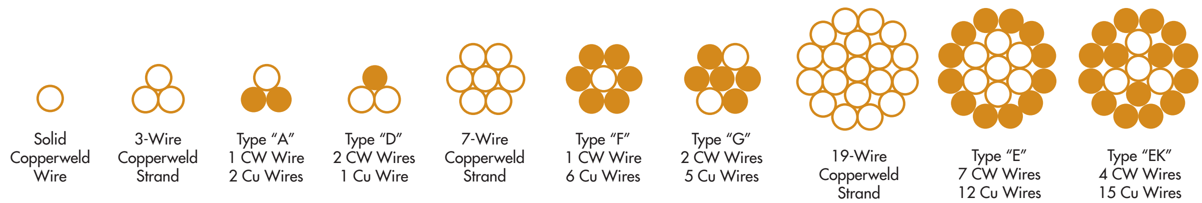
ELECTRICAL CHARACTERISTICS OF COPPERWELD®/COPPER COMPOSITE STRANDED CONDUCTORS



The electrical properties of Copperweld®/Cu and Copperweld® conductors for determining the electrical performance of transmission and distribution lines are listed in the accompanying tables. These tables include values of resistance, inductive and shunt capacitive reactances, and the geometric mean radius, together with the approximate ampacity for 60 hertz frequency.

RESISTANCE

The resistance of Copperweld®/Cu conductors is shown for temperatures of 25°C. and 50° and those of Copperweld® conductors for 25°C. and 75°C. The 25°C. values are for small currents, approximately equivalent to 1000 amperes per square inch of copper conductance. The higher temperature values are for heavy currents, or approximately 75% of the ampacities shown in the table. Resistance figures are based on 97.5% conductivity copper.

INDUCTIVE AND CAPACITIVE REACTANCE

The inductive reactances are given for the conductors at one foot spacing with supplementary tables of adders for spacings greater than one foot. The basic values are tabulated in Table 1 and 4 as x_a (Inductive). The adders x_d are the same for all conductors and are tabulated in Table 2. As the inductive reactances are substantially independent of the current these values are applicable for either small or large current. The relation between the inductive reactance for one foot spacing and geometric mean radius is shown in the following formulas:

$$x_a = .2794 \log_{10} \frac{1}{\text{G.M.R.}}$$

$$\text{G.M.R.} = \frac{\text{Conductor radius in feet}}{\text{Antilog}_{10}\ .1083\ \mu}$$

$$x_{int} = .03026$$

where: x_a = Inductive reactance (60 hertz) for 1 ft. spacing — ohms per conductor per mile.

G.M.R. = Geometric mean radius in feet.

μ = Effective permeability ratio of conductor.

x_{int} = Internal reactance (60 hertz).

The capacitive reactances are also given for conductors at one foot spacing with supplementary tables for spacings greater than one foot. Basic values for each conductor are tabulated in Tables 1 and 4 as x'_a (Capacitive) and the capacitive reactance adders x'_d are tabulated in Table 3.

AMPACITY

The ampacities are in accordance with the Schurig and Frick formula, assuming a two foot per second cross wind and an emissivity factor of 0.5 (average tarnished surface). The data for Copperweld®/COPPER conductors are based on a 50°C. rise over a 25°C. ambient or a maximum temperature of 75°C. For Copperweld conductors, the temperature rise is 100°C. over a 25°C. ambient or a maximum temperature of 125°C. These maximum temperatures represent permissible values to which the conductor can be subjected, without annealing or loss of strength.

NOTE: Properties noted in these data sheets are typical values for standard applications. If your application requires performance values beyond those noted, please contact Copperweld's Engineering Support Center at **engineering@copperweld.com** or **+1.931.433.7177**. Material selection, varying composition and processing conditions all provide flexibility in how Copperweld can deliver exactly the product you need. Bimetallic conductors from Copperweld offer many distinct advantages, and our engineering team works in concert with our clients to determine the proper components for the stringent requirements of their products.

TABLE 1

ELECTRICAL CHARACTERISTICS OF COPPERWELD/COPPER CONDUCTORS

CONDUCTOR	RESISTANCE-OHMS PER CONDUCTOR PER MILE				REACTANCE PER CONDUCTOR PER MILE ONE FOOT SPACING		GEOMETRIC MEAN RADIUS at 60 Hz	APPROX. AMPACITY† at 60 Hz
	r_a at 25°C (77°F) SMALL CURRENTS		r_a at 50°C (122°F) CURRENT-APPROX. 75% OF AMPACITY		x_a INDUCTIVE	x'_a CAPACITIVE		
	D.C.	60 Hertz	D.C.	60 Hertz	Ω at 60 Hz	MΩ at 60 Hz	(feet)	(amps)
350 E	0.1658	0.1812	0.1812	0.204	0.463	0.1014	0.02200	660
350 EK	0.1658	0.1705	0.1812	0.1882	0.450	0.1034	0.02450	680
300 E	0.1934	0.209	0.211	0.235	0.473	0.1037	0.02040	600
300 EK	0.1934	0.1981	0.211	0.219	0.460	0.1057	0.02270	610
250 E	0.232	0.248	0.254	0.279	0.484	0.1064	0.01859	540
250 EK	0.232	0.237	0.254	0.261	0.471	0.1084	0.02070	540
4/0 E	0.274	0.290	0.300	0.326	0.493	0.1088	0.01711	480
4/0 G	0.273	0.298	0.299	0.342	0.517	0.1103	0.01409	460
4/0 EK	0.274	0.279	0.300	0.308	0.481	0.1109	0.01903	490
4/0 F	0.273	0.287	0.299	0.322	0.505	0.1120	0.01558	470
3/0 E	0.346	0.361	0.378	0.407	0.508	0.1123	0.01521	420
3/0 J	0.344	0.372	0.377	0.428	0.541	0.1118	0.01156	410
3/0 G	0.344	0.369	0.377	0.423	0.531	0.1137	0.01254	400
3/0 EK	0.346	0.351	0.378	0.386	0.495	0.1143	0.01697	420
3/0 F	0.344	0.358	0.377	0.401	0.519	0.1155	0.01388	410
2/0 K	0.434	0.466	0.475	0.535	0.570	0.1129	0.00912	360
2/0 J	0.434	0.462	0.475	0.530	0.555	0.1152	0.01029	350
2/0 G	0.434	0.459	0.475	0.525	0.545	0.1171	0.01119	350
2/0 F	0.434	0.448	0.475	0.501	0.533	0.1189	0.01235	350
1/0 K	0.548	0.579	0.599	0.664	0.584	0.1164	0.00812	310
1/0 J	0.548	0.576	0.599	0.659	0.569	0.1186	0.00917	310
1/0 G	0.548	0.573	0.599	0.654	0.559	0.1206	0.00996	310
1/0 F	0.548	0.562	0.599	0.627	0.547	0.1224	0.01099	310
1N	0.691	0.726	0.755	0.832	0.614	0.1171	0.00638	280
1K	0.691	0.722	0.755	0.825	0.598	0.1198	0.00723	270
1J	0.691	0.719	0.755	0.820	0.583	0.1221	0.00817	270
1G	0.691	0.716	0.755	0.815	0.573	0.1240	0.00887	260
1F	0.691	0.705	0.755	0.786	0.561	0.1258	0.00980	270

* Resistance at 50°C. total temperature, based on ambient of 25°C plus 25°C rise due to heating effect of current. The approximate magnitude of current necessary to produce the 25°C rise is 75% of the "Approximate Ampacity at 60 Hertz"

† Based on a conductor temperature of 75°C and an ambient of 25°C.

TABLE 2

INDUCTIVE REACTANCE ADDERS FOR SEPARATIONS GREATER THAN ONE FOOT

X_d-EQUIVALENT SEPARATION IN FEET

feet	0	1	2	3	4	5	6	7	8	9
0	-	0	0.084	0.133	0.168	0.195	0.217	0.236	0.252	0.267
10	0.279	0.291	0.302	0.311	0.320	0.329	0.336	0.344	0.351	0.357
20	0.364	0.369	0.375	0.380	0.386	0.391	0.395	0.400	0.404	0.409
30	0.413	0.417	0.421	0.424	0.428	0.431	0.435	0.438	0.441	0.445

Note: Total inductive reactance equals inductive reactance for one foot plus adder for conductor separation

Impedance (line to neutral) in Ω/conductor for line N miles long **Z = N (ra + j (xa + xd))**

TABLE 1 (CONTINUED)

ELECTRICAL CHARACTERISTICS OF COPPERWELD/COPPER CONDUCTORS

CONDUCTOR	RESISTANCE-OHMS PER CONDUCTOR PER MILE				REACTANCE PER CONDUCTOR PER MILE ONE FOOT SPACING		GEOMETRIC MEAN RADIUS at 60 Hz	APPROX. AMPACITY† at 60 Hz
	r_a at 25°C (77°F) SMALL CURRENTS		r_a at 50°C (122°F) CURRENT-APPROX. 75% OF AMPACITY		x_a INDUCTIVE Ω at 60 Hz	x'_a CAPACITIVE MΩ at 60 Hz		
	D.C.	60 Hertz	D.C.	60 Hertz			(feet)	(amps)
2P	0.871	0.909	0.952	1.040	0.643	0.1172	0.00501	250
2N	0.871	0.906	0.952	1.035	0.627	0.1205	0.00568	240
2K	0.871	0.902	0.952	1.028	0.612	0.1232	0.00644	240
2J	0.871	0.899	0.952	1.022	0.598	0.1255	0.00727	230
2A	0.869	0.882	0.950	0.979	0.592	0.1241	0.00763	240
2G	0.871	0.896	0.952	1.016	0.587	0.1275	0.00790	230
2F	0.871	0.885	0.952	0.985	0.575	0.1292	0.00873	230
3P	1.098	1.136	1.200	1.296	0.657	0.1207	0.00445	220
3N	1.098	1.133	1.200	1.289	0.641	0.1239	0.00506	210
3K	1.098	1.129	1.200	1.281	0.626	0.1266	0.00574	210
3J	1.098	1.126	1.200	1.275	0.611	0.1289	0.00648	200
3A	1.096	1.109	1.198	1.229	0.606	0.1275	0.00679	210
4P	1.385	1.423	1.514	1.616	0.671	0.1241	0.00397	190
4N	1.385	1.420	1.514	1.610	0.655	0.1274	0.00451	180
4D	1.382	1.399	1.511	1.542	0.628	0.1256	0.00566	190
4A	1.382	1.395	1.511	1.545	0.620	0.1310	0.00604	180
5P	1.747	1.785	1.909	2.02	0.685	0.1275	0.00353	160
5D	1.742	1.759	1.905	1.939	0.642	0.1290	0.00504	160
5A	1.742	1.755	1.905	1.941	0.634	0.1345	0.00538	160
6D	2.20	2.22	2.40	2.44	0.656	0.1325	0.00449	140
6A	2.20	2.21	2.40	2.44	0.648	0.1379	0.00479	140
6C	2.20	2.21	2.40	2.44	0.651	0.1386	0.00469	130
7D	2.77	2.79	3.03	3.07	0.670	0.1359	0.00400	120
7A	2.77	2.78	3.03	3.07	0.658	0.1388	0.00441	120
8D	3.49	3.51	3.82	3.86	0.684	0.1393	0.00356	110
8A	3.49	3.51	3.82	3.87	0.672	0.1422	0.00394	100
8C	3.49	3.51	3.82	3.86	0.679	0.1453	0.00373	100
9½D	4.91	4.93	5.37	5.42	0.712	0.1462	0.00283	85

* Resistance at 50°C total temperature, based on ambient of 25°C plus 25°C rise due to heating effect of current. The approximate magnitude of current necessary to produce the 25°C rise is 75% of the "Approximate Ampacity at 60 Hertz"

† Based on a conductor temperature of 75°C.and an ambient of 25°C.

TABLE 3

SHUNT CAPACITIVE REACTANCE ADDERS FOR SEPARATION GREATER THAN ONE FOOT

X'_d-EQUIVALENT SEPARATION IN FEET

Feet	0	1	2	3	4	5	6	7	8	9
0	-	0	0.021	0.033	0.041	0.048	0.053	0.058	0.062	0.065
10	0.068	0.071	0.074	0.076	0.078	0.080	0.082	0.084	0.086	0.087
20	0.089	0.090	0.092	0.093	0.094	0.096	0.097	0.098	0.099	0.100
30	0.101	0.102	0.103	0.104	0.105	0.106	0.106	0.107	0.108	0.109

Note: Total Shunt capacitive reactance equals shunt capacitive reactance for one foot plus adder for conductor separation

Shunt Capacity Reactance (line to neutral) in MΩ/conductor for line N miles long $X' = -j\frac{x'_a + x'_d}{N}$

TABLE 4

ELECTRICAL CHARACTERISTICS OF COPPERWELD/COPPER CONDUCTORS

	RESISTANCE-OHMS PER CONDUCTOR PER MILE				REACTANCE PER CONDUCTOR PER MILE ONE FOOT SPACING			
	r_a at 25°C (77°F) SMALL CURRENTS		r_a at 75°C (167°F) CURRENT-APPROX. 75% OF AMPACITY		x_a INDUCTIVE	x'_a CAPACITIVE	GEOMETRIC MEAN RADIUS at 60 Hz	APPROX. AMPACITY† at 60 Hz
CONDUCTOR	D.C.	60 Hertz	D.C.	60 Hertz	Ω at 60 Hz	MΩ at 60 Hz	(feet)	(amps)
40% Conductivity								
7/8" 19 No. 5	0.229	0.254	0.272	0.391	0.539	0.0971	0.01175	690
13/16" 19 No. 6	0.289	0.314	0.343	0.472	0.553	0.1005	0.01046	610
23/32" 19 No. 7	0.365	0.390	0.433	0.573	0.567	0.1040	0.00931	530
21/32" 19 No. 8	0.460	0.485	0.546	0.698	0.582	0.1074	0.00829	470
9/16" 19 No.9	0.580	0.605	0.688	0.853	0.595	0.1109	0.00739	410
5/8" 7 No. 4	0.492	0.512	0.584	0.680	0.587	0.1088	0.00792	470
9/16" 7 No. 5	0.620	0.640	0.736	0.840	0.601	0.1122	0.00705	410
1/2" 7 No. 6	0.782	0.802	0.928	1.040	0.615	0.1157	0.00628	350
7/16" 7 No. 7	0.986	1.006	1.170	1.291	0.629	0.1191	0.00559	310
3/8" 7 No. 8	1.244	1.264	1.476	1.606	0.644	0.1226	0.00497	270
11/32" 7 No. 9	1.568	1.588	1.861	2.00	0.658	0.1260	0.00443	230
5/16" 7 No. 10	1.978	1.998	2.35	2.50	0.671	0.1294	0.00395	200
3 No. 5	1.445	1.457	1.714	1.772	0.617	0.1221	0.00621	250
3 No. 6	1.821	1.833	2.16	2.22	0.631	0.1255	0.00553	220
3 No. 7	2.30	2.31	2.73	2.79	0.645	0.1289	0.00492	190
3 No. 8	2.90	2.91	3.44	3.51	0.659	0.1324	0.00439	160
3 No. 9	3.65	3.66	4.33	4.41	0.673	0.1358	0.00391	140
3 No. 10	4.61	4.62	5.46	5.55	0.687	0.1392	0.00348	120
3 No. 12	7.32	7.34	8.69	8.78	0.715	0.1462	0.00276	90
No. 2 Solid	2.14	2.14	2.54	2.54	0.612	0.1345	0.00645	190
No. 4 Solid	3.41	3.41	4.05	4.05	0.640	0.1415	0.00506	140
No. 6 Solid	5.42	5.42	6.44	6.44	0.669	0.1483	0.00403	100
30% Conductivity								
7/8" 19 No. 5	0.306	0.331	0.363	0.499	0.592	0.0971	0.00758	620
13/16" 19 No. 6	0.386	0.411	0.458	0.605	0.606	0.1005	0.00675	540
23/32" 19 No. 7	0.486	0.511	0.577	0.737	0.621	0.1040	0.00601	470
21/32" 19 No. 8	0.613	0.638	0.728	0.902	0.635	0.1074	0.00535	410
9/16" 19 No.9	0.773	0.798	0.917	1.106	0.649	0.1109	0.00477	360
5/8" 7 No. 4	0.656	0.676	0.778	0.887	0.640	0.1088	0.00511	410
9/16" 7 No. 5	0.827	0.847	0.981	1.099	0.654	0.1122	0.00455	360
1/2" 7 No. 6	1.042	1.062	1.237	1.364	0.668	0.1157	0.00405	310
7/16" 7 No. 7	1.315	1.335	1.560	1.697	0.683	0.1191	0.00361	270
3/8" 7 No. 8	1.658	1.678	1.967	2.12	0.697	0.1226	0.00321	230
11/32" 7 No. 9	2.09	2.11	2.48	2.64	0.711	0.1260	0.00286	200
5/16" 7 No. 10	2.64	2.66	3.13	3.30	0.725	0.1294	0.00255	170
3 No. 5	1.926	1.938	2.29	2.35	0.654	0.1221	0.00457	220
3 No. 6	2.43	2.44	2.88	2.95	0.668	0.1255	0.00407	190
3 No. 7	3.06	3.07	3.63	3.71	0.682	0.1289	0.00363	160
3 No. 8	3.86	3.87	4.58	4.66	0.696	0.1324	0.00323	140
3 No. 9	4.87	4.88	5.78	5.86	0.710	0.1358	0.00288	120
3 No. 10	6.14	6.15	7.28	7.38	0.724	0.1392	0.00257	110
No. 2 Solid	2.86	2.86	3.40	3.40	0.662	0.1345	0.00427	160
No. 4 Solid	4.54	4.54	5.40	5.40	0.690	0.1415	0.00339	120
No. 6 Solid	7.22	7.22	8.58	8.58	0.718	0.1483	0.00269	90

* Resistance at 75°C total temperature, based on ambient of 25°C plus 50°C rise due to heating effect of current. The approximate magnitude of current necessary to produce the 50°C rise is 75% of the "Approximate Ampacity at 60 Hertz"

† Based on a conductor temperature of 125°C and an ambient of 25°C. A 2 ft/s wind speed and Emissivity = 0.5