Data Bulletin

Using Fine Stranded Wire with Mechanical Lugs

Retain for future use.

Fine stranded wire (sometimes called welding cable) is often used in control equipment by original equipment manufacturers. Compared to standard stranded copper cable, it is very flexible and bends easily. Fine stranded wire differs from standard copper wire in two respects: Strand size and outside diameter.

The size of the strands, how many strands are used per cable and the outside diameter of the cable depends on what class stranding is used. There are five major classifications of stranding. Class AA has the least amount of stranding (next to solid cable). Classes A, B and C have intermediate degrees of stranding and Class D is the most finely stranded cable.

The National Electrical Code lists Class B stranding in its table of conductor properties (See Table 1). Fine stranded wire falls into Classes C and D and also consists of custom made cable with stranding greater than that of Class B stranded conductors.

Table 2 lists the types of stranding for Class AA through Class D conductors, including the number of wires (or Strands) used to make the cable, the diameter of each strand and the overall diameter of the cable.

Notice that as the number of strands increases for a given cross-section, the outside diameter of the cable also increases. Most terminations, such as mechanical and compression lugs, are sized using Class B conductors. When fine stranded wire is used, up to two wire sizes may be lost for a given termination due to the larger outside cable diameter of fine stranded wire. Lacing of cables is recommended if using fine stranded wire.

Table 1: Conductor Properties

Size AWG/ MCM	Area Cir. Mils	Conductors			
		Stranding		Overall	
		Quantity	Diam. In.	Diam. In.	Area in.^{2}
18	1620	1	—	0.040	0.001
18	1620	7	0.015	0.046	0.002
16	2580	1	—	0.051	0.002
16	2580	7	0.019	0.058	0.003
14	4110	1	—	0.064	0.003
14	4110	7	0.024	0.073	0.004
12	6530	1	—	0.081	0.005
12	6530	7	0.030	0.092	0.006
10	10380	1	—	0.102	0.008
10	10380	7	0.038	0.116	0.011
8	16510	1	—	0.128	0.013
8	16510	7	0.049	0.146	0.017
6	26240	7	0.061	0.184	0.027
4	41740	7	0.077	0.232	0.042
3	52620	7	0.087	0.260	0.053
2	66360	7	0.097	0.292	0.067
1	83690	19	0.066	0.332	0.087
1/0	105600	19	0.074	0.373	0.109
2/0	133100	19	0.084	0.419	0.138
3/0	167800	19	0.094	0.470	0.173
4/0	211600	19	0.106	0.528	0.219
250	—	37	0.082	0.575	0.260
300	—	37	0.090	0.630	0.312
350	—	37	0.097	0.681	0.364
400	—	37	0.104	0.728	0.416
500	—	37	0.116	0.813	0.519
600	—	61	0.992	0.893	0.626
700	—	61	0.107	0.964	0.730
750	—	61	0.111	0.998	0.782
800	—	61	0.114	1.03	0.834
900	—	61	0.122	1.09	0.940
1000	—	61	0.128	1.15	1.04
1250	—	91	0.117	1.29	1.30
1500	—	91	0.128	1.41	1.57
1750	—	127	0.117	1.52	1.83
2000	—	127	0.128	1.63	2.09

Conductors with compact and compressed stranding have about 9 percent and 3 percent, respectively, smaller bare conductor diameters than those shown. See Table 5A for actual compact cable dimensions.

Class B stranding is listed as well as solid for some sizes. Its overall diameter and area is that of its circumscribing circle.

(FPN:) The construction information is per NEMA WC8-1992.

From Table 8, Chapter 9 of the 1999 NEC.

**Table 2: Types of Stranding[a]
Construction Requirements of Concentric-Lay-Stranded Copper Conductor
(Ultimate Strength for Class — A, AA & B. See Page 9)**

Size American Wire Gage, or MCM	Class AA			Class A			Class B (Standard)			Class C			Class D		
	No. Of Wires	Diam. Of Wires, Inches	Diam. Of Cable, Inches	No. Of Wires	Diam. Of Wires, Inches	Diam. Of Cable, Inches	No. Of Wires	Diam. Of Wires, Inches	Diam. Of Cable, Inches	No. Of Wires	Diam. Of Wires, Inches	Diam. Of Cable, Inches	No. Of Wires	Diam. Of Wires, Inches	Diam. Of Cable, Inches
1,000	37	.1644	1.151	61	.1280	1.152	61	.1280	1.152	91	.1048	1.153	127	.0887	1.154
900	37	.1560	1.092	61	.1215	1.094	61	.1215	1.094	91	.0994	1.095	127	.0842	1.096
800	37	.1470	1.029	61	.1145	1.031	61	.1145	1.031	91	.0938	1.032	127	.0794	1.032
750	37	.1424	.997	61	.1109	.998	61	.1109	.998	91	.0908	.999	127	.0768	1.000
700	37	.1375	.963	61	.1071	.964	61	.1071	.964	91	.0877	.965	127	.0742	.966
650	37	.1325	.928	61	.1032	.929	61	.1032	.929	91	.0845	.930	127	.0715	.930
600	37	.1273	.891	37	.1273	.891	61	.0992	.893	91	.0812	.893	127	.0687	.894
550	37	.1219	.853	37	.1219	.853	61	.0950	.855	91	.0777	.855	127	.0658	.855
500	19	.1622	.811	37	.1162	.813	37	.1162	.813	61	.0905	.815	91	.0741	.817
450	19	.1539	.770	37	.1103	.772	37	.1103	.772	61	.0859	.773	91	.0703	.774
400	19	.1451	.726	19	.1451	.726	37	.1040	.728	61	.0810	.730	91	.0663	.731
350	19	.1708	.710	19	.1357	.679	37	.0973	.681	61	.0757	.683	91	.0620	.684
300	12	.1581	.657	19	.1257	.629	37	.0900	.630	61	.0701	.632	91	.0574	.633
250	12	.1443	.600	19	.1147	.574	37	.0822	.575	61	.0640	.577	91	.0524	.578
0000	7	.1739	.522	7	.1739	.522	19	.1055	.528	37	.0756	.529	61	.0589	.530
000	7	.1548	.464	7	.1548	.464	19	.0940	.470	37	.0673	.471	61	.0524	.471
00	7	.1379	.414	7	.1379	.414	19	.0837	.418	37	.0600	.419	61	.0467	.419
0	7	.1228	.368	7	.1228	.368	19	.0745	.373	37	.0534	.376	61	.0416	.376
1	3	.1670	.360	7	.1093	.328	19	.0664	.332	37	.0476	.333	61	.0370	.333
2	3	.1487	.320	7	.0974	.292	7	.0974	.292	19	.0591	.295	37	.0424	.296
3	3	.1325	.285	7	.0867	.260	7	.0867	.260	19	.0526	.261	37	.0377	.262
4	3	.1180	.254	7	.0772	.232	7	.0772	.232	19	.0469	.230	37	.0336	.231
5							7	.0688	.206	19	.0417	.209	37	.0299	.210
6							7	.0612	.184	19	.0372	.186	37	.0266	.186
7	—	—	—	—	—	—	7	.0545	.164	19	.0331	.166	37	.0237	.166
8							7	.0486	.146	19	.0295	.147	37	.0211	.148
9							7	.0432	.130	19	.0262	.131	37	.0188	.132
10							7	.0385	.116	19	.0234	.117	37	.0167	.117
12							7	.0305	.092	19	.0185	.093	37	.0133	.093
14	—	—	—	—	—	—	7	.0242	.073	19	.0147	.074	37	.0105	.074
16							7	.0192	.058	19	.0117	.058	—	—	—
18							7	.0152	.046	19	.0092	.046	—	—	—
20	—	—	—	—	—	—	7	.0121	.036	19	.0073	.037	—	—	—

a. The sizes of conductors which have been marked with an asterisk provide for one or more schedules of preferred series, and are commonly used in the industry. The sizes not marked are given simply as a matter of reference and it is suggested that their use be discouraged.

From: Technical Data
Anderson Electrical Connectors
Square D Co.

APPLICATION

Because of the number and small size of the strands, fine stranded wire terminations in mechanical lugs are susceptible to a number of problems if not properly applied and installed. Two of the most common problems associated with using fine stranded wire are overheating of the connection and wire pullout.

The reasons for this can be seen in Figure 1. Note that the width of the opening in the lug is greater than the width of the wire binding screw. As the wire binding screw is advanced into the lug, the strands are displaced to the sides of the screw. Some of the strands may actually be drawn between the threads and the lug body. This condition leads to a false torque indication which may result in overheating and easy wire pullout. If the lug opening is much larger than the wire binding screw, all of the strands may be displaced and the screw will bottom out in the lug. This also results in a false torque indication and the same poor connection results.

A solution to these problems is to use sleeves, around the strands of the wire. Conductor sleeves are defined, as any moderately thin copper shim stock material (3/1000 to 20/1000 thick) that, when wrapped around the exposed conductor surface, will contain the wire strands as a single compact mass. The sleeve will:

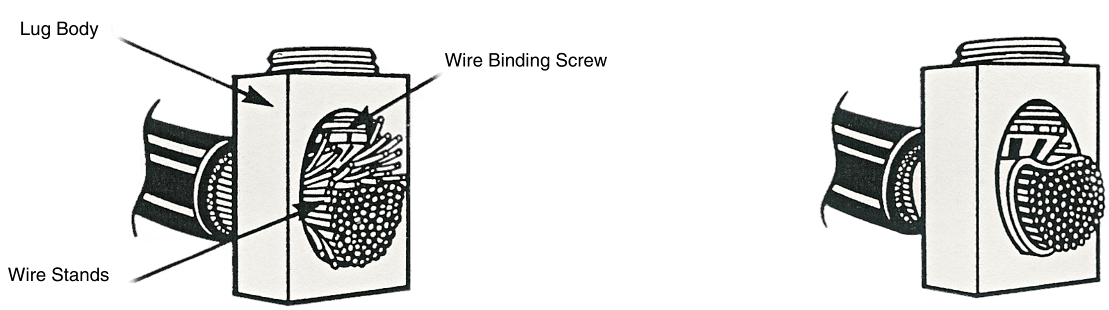
1. Keep the strands together and prevent fraying or spreading out as the cable is inserted into the lug body.
2. Hold the strands tightly together as the wire binding screw is tightened onto the cable. This prevents the strands from being forced up around the sides of the wire binding screw. The result is a secure mechanical and electrical connection.

In order to determine the suitability of fine stranded wire for use with Square D products, a number of tests have been conducted on Square D circuit breaker mechanical lugs and power distribution connectors. These are the same type of tests that UL requires for standard conductors. The set of tests includes:

1. **A cycling test.** A lead is cycled on and off for a specified number of operations and the connection checked for loosening due to thermal expansion and contraction, and for thermal stability.
2. **A static heating test.** From a cold start a load is placed on the wire and the maximum rated current is allowed to flow. UL requires that the measured temperature rise does not exceed 50°C (122°F) above ambient. This test is repeated following the secureness and pullout test.
3. **Secureness and pullout tests.** Tension is placed on the wire to determine if it is securely held in the lug at the specified wire binding screw torque.

These tests were conducted using a typical representative group of readily available fine stranded wire sizes. Due to the almost unlimited number of custom stranding combinations available, it is not practical to test each fine stranded wire type or size.

Figure 1: Using Fine Stranded Wire with Mechanical Lugs



Without Sleeve: Fine strands are displaced around sides of wire binding screw. Some strands may be forced between threads of wire binding screw and lug body.
Result: Wire may not be held securely - could pull-out. False torque indication may be present. Connection could overheat.

With Sleeve: Fine strands are held tightly together by sleeve under pressure of wire binding screw.
Result: A secure mechanical and electrical connection.

Schneider Electric
3700 Sixth Street SW
Cedar Rapids, Iowa 52404 USA
1-888-SquareD (1-888-778-2733)
www.SquareD.com