

BENDING RADII AND PULLING TENSIONS

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“Training” is the positioning of the cable when NOT under tension. “Bending” is under tension. The minimum bending radius applies to the inner surface of the cable and not to the cable axis. “Sidewall pressure” or loading is the radial force exerted on a cable when pulled around a bend or sheave. Excessive sidewall pressure will crush the cable.

SIDEWALL LOADING

Where **T** is tension out of a bend, in pounds, and **R** is the radius of a bend, in feet.

$$\begin{aligned} \text{1/C per Conduit: SW} &= \frac{T}{R} \\ \text{3-1/C Cradled: SW} &= \left[\frac{3w-2}{3} \right] \frac{T}{R} \\ \text{3-1/C Triangular: SW} &= \left[\frac{w}{2} \right] \frac{T}{R} \end{aligned}$$

TYPICAL SIDEWALL LOADINGS	LBS./FT.
600v Non-shielded Control	300
600v & 1KV Non-shielded EP and XLP	500
5 & 15 KV Unishield & EP/XLP	500
25-35 KV Power	300
Interlocked Armored Cable (All Voltage Classes)	300

MINIMUM BENDING RADII

POWER CABLES WITHOUT METALLIC SHIELDING, UP TO 600V

The minimum bending radii for both single and multiple-conductor cables with or without lead sheath and without metallic shielding are as follows:

Thickness of Conductor Insulation in Mils	Minimum Bending Radius as a Multiple of Cable Diameter		
	Overall diameter of Cable in Inches		
	1,000 and Less	1,001 - 2,000	2,001 and Over
155 and Less	4	5	6
170-310	5	6	7
325 and Over	-	7	8

POWER CABLES WITH METALLIC AND LEAD COVERED SHIELDING (ALL VOLTAGES)

1. For all shielded cables, the minimum bending radius is twelve times (12) the overall diameter of the completed cable.

POWER CABLES OVER 600 VOLTS, NON-SHIELDED, NON-ARMORED

1. The minimum bending radius for all cables is eight times (8) the overall cable diameter.

INTERLOCKED ARMORED CABLE, ALL VOLTAGES

1. The minimum bending radius for cables with non-shielded conductors is seven times (7) the armor O.D.

2. The minimum bending radius for cables with shielded conductors is twelve times (12) the diameter of one phase conductor/seven times (7) the armor O.D., whichever is larger.

PULLING TENSIONS

The following recommendations are based on a study sponsored by the ICEA. These recommendations may be modified if experience and more exact information so indicate.

A. Maximum Pulling Tension on Cable

1. With pulling eye attached to copper conductors, the maximum pulling tension in pounds should not exceed 0.008 times cir-mil area.
2. With pulling eye attached to ¾ aluminum conductors, the maximum pulling tension in pounds should not exceed 0.006 times cir-mil area.

$$T_M = 0.008 \times n \times CM$$

Where:

T_M = Max Tension (Lbs.)
 n = Number of Conductors
 CM = Cir-Mil Area of Each Conductor

3. With cable grip over a lead sheath, the maximum pulling tension in pounds should not exceed 1,500 lbs./sq. inch of lead sheath cross-sectional area for commercial lead

$$T_M = 4,712t (D-t)$$

Where:

t = Sheath Thickness (in.)
 D = Overall Diameter of Cable (in.)

4. With cable grip over a non-lead cable, the maximum pulling tension should not exceed 1,000 lbs. and may not exceed the maximum tension based on 0.008 or 0.006 x total conductor area.

5. When more than three conductors are pulled together, reduce the pulling tension 20%

B. Maximum Permissible Pulling Lengths

$$L_M = \frac{T_M}{CW}$$

Where:

L_M = Pulling Length, (Ft. Straight Section)
 T_M = Max Tension (Lbs.)

C. Pulling Tension Requirements in ducts or Conduits:

1. For straight sections, the pulling tension in pounds equals the length of duct multiplied by the weight per foot of cable and the coefficient of friction (paragraph B, above)

2. For curved sections, the following formula applies:

$$T_T = T_2 + T_1 e^{fa}$$

Where:

T_2 = Tension for Straight Section at Pulling End (Lbs.)
 T_1 = Tension for Straight Section at Feeding End (Lbs.)
 T_T = Total Tension
 a = Angle of Bend in Radians (1 Radian = 57.3 deg.)
 F = Coefficient of Friction (Usually 0.5)
 $e^{fa} = \log_{10}^{-1} \frac{fa}{2.303}$
 e = Napierian Logarithm Base = 2.718

3. The maximum pulling tension in pounds shall not exceed 300 times the radius of curvature of the duct expressed in ft.

CONDUCTORS IN PARALLEL OR AS ASSEMBLIES SOFT DRAWN COPPER OR HARD DRAWN ALUMINUM

The following maximum tensions are for direct attachment to the conductor. However, the pulling force must not exceed the smallest value of 1) conductor tension, or 2) pulling device tension, or 3) sidewall load.

Number of Conductors	1	2	3	4	5	6
AWG/kcmil	Maximum Allowable conductor tension (LBS)					
20	8	16	24	26	33	39
18	13	26	39	41	52	62
16	21	41	62	66	83	99
14	33	66	99	100	130	150
12	52	100	150	160	200	250
11	66	130	190	210	260	310
10	83	160	240	260	330	390
9	100	200	310	330	410	500
8	130	260	390	420	520	630
6	210	420	630	670	840	1000
4	330	660	1000	1060	1330	1600
3	420	840	1260	1340	1680	2020
2	530	1060	1590	1690	2120	2540
1	670	1330	2000	2140	2670	3210
1/0	840	1690	2530	2700	3370	4050
2/0	1060	2130	3190	3400	4250	5110
3/0	1340	2680	4020	4290	5370	6440
4/0	1690	3380	5070	5410	6500	6500
250	2000	4000	6000	6400	6500	6500
300	2400	4800	6500	6500	6500	6500
350	2800	5600	6500	6500	6500	6500
400	3200	6400	6500	6500	6500	6500
450	3600	6500	6500	6500	6500	6500
500	4000	6500	6500	6500	6500	6500
600	4800	6500	6500	6500	6500	6500
700	5000	6500	6500	6500	6500	6500
750	5000	6500	6500	6500	6500	6500
800	5000	6500	6500	6500	6500	6500
900	5000	6500	6500	6500	6500	6500
1000	5000	6500	6500	6500	6500	6500

This chart may also be used for hard tempered aluminum conductors. However, use 1/2 of these chart values for all other UL labeled cables having aluminum conductors, such as THW, XHHW wire or SE cables.

MULTICONDUCTOR CABLES HAVING EQUAL-SIZED CONDUCTORS, WITHOUT SUBASSEMBLIES; SOFT DRAWN COPPER

The following maximum tensions are for direct attachment to the conductor. However, the pulling force must not exceed the smallest value of 1) conductor tension, or 2) pulling device tension, or 3) sidewall load.

AWG	20	18	16	14	12	11	10	9
Number of Conductors	Maximum Allowable conductor tension (LBS)							
2	16	26	41	66	100	130	160	200
3	24	39	62	99	150	190	240	310
4	33	52	83	130	200	260	330	410
5	41	65	100	160	260	320	410	520
6	49	78	120	190	310	390	490	620
7	49	78	120	190	310	390	490	620
8	52	83	130	210	330	420	530	670
9	59	93	140	230	370	470	590	750
10	65	100	160	260	410	520	660	830
11	72	110	180	280	460	570	730	920
12	78	120	190	310	500	630	790	1000
13	85	130	210	340	540	680	860	1000
14	91	140	130	360	580	730	930	1000
15	98	150	240	390	620	790	990	1000
16	100	160	260	420	660	840	1000	1000
17	110	170	280	440	710	890	1000	1000
18	110	180	290	470	750	940	1000	1000
19	120	190	310	500	790	1000	1000	1000
20	130	200	330	520	830	1000	1000	1000
22	140	220	360	570	910	1000	1000	1000
24	150	240	390	630	1000	1000	1000	1000
26	170	270	420	680	1000	1000	1000	1000
28	180	290	460	730	1000	1000	1000	1000
30	190	310	490	780	1000	1000	1000	1000
32	200	330	520	840	1000	1000	1000	1000
34	220	350	560	890	1000	1000	1000	1000
36	230	370	590	940	1000	1000	1000	1000
38	240	390	620	1000	1000	1000	1000	1000
40	260	410	660	1000	1000	1000	1000	1000
42	270	430	690	1000	1000	1000	1000	1000
44	280	450	720	1000	1000	1000	1000	1000
46	300	470	760	1000	1000	1000	1000	1000
48	310	490	790	1000	1000	1000	1000	1000
50	320	510	820	1000	1000	1000	1000	1000

The Maximum Limit is 1,000 Lbs.