Checklist for Specifications

Control Cable

❑ Conductor Tape
❑ AWG
❑ Solid
___ Class B, concentric
___ Flexible
❑ Bare/Coated
❑ Insulation
❑ Jacket
❑ Temperature rating
❑ Voltage rating
❑ Individual Conductor Listings
❑ Number of Conductors
❑ Identification Method
___ Color code
___ Numbering
___ Tags
❑ Grounding
___ Bare/Coated
___ Size
___ Insulated

Power Cable

❑ Size, AWG or kcmil
❑ Conductor Type (metal)
❑ Stranding
___ Class B, compact
___ Class B, concentric
___ Class C
___ Other
❑ Bare/Coated
❑ Conductor Shielding
___ Extruded
___ Tape
❑ Insulation
___ EPR
___ EVA
___ FEP
___ FR-EP
___ LSZH
___ Polyethylene/PVC
___ PVC/Nylon
___ Silicone
___ XLPE
___ Other
❑ Insulation Level
___ 100%
___ 133%
❑ Insulation Shielding
___ Extruded
___ Tape
❑ Metallic Shielding
___ Bare/Coated
___ Helical copper tapes
___ Helical wires
___ Longitudinal drain wires
___ Other
❑ Jacket
___ CPE
___ CSPE
___ LSZH/XLPO
___ Neoprene
___ Polyurethane
___ PVC
___ XLPE
___ XL-CPE
___ XL-LSZH
___ Other
❑ Cable Assembly
___ Cabled
___ Multiconductor
___ Other
❑ Grounding Conductors
___ Bare/Coated
___ Insulated/Uninsulated
___ Quantity
___ Size
❑ Neutral Conductors
___ Bare/Coated
___ Fillers
___ Flame retardant
___ Fiber
___ Quantity
___ Insulated
___ Paper
___ Other
___ Size
❑ Covering
___ Corrugated continuous welded armor
___ Interlocked armor
___ Lead
___ Nonmetallic
___ Other
❑ Color
❑ Voltage rating
❑ Temperature rating
❑ Approvals

General Checklist

❑ Standards
___ AEIC
___ CANENA
___ CSA
___ ICEA
___ IEC
___ IEEE
___ UL
___ Other
❑ Testing Procedures
___ AEIC
___ CAN ENA
___ CSA
___ ICEA
___ IEC
___ IEEE
___ UL
___ Other
❑ Special Requirements
___ Cold bend
___ Direct burial
___ Flame retardant
___ Oil resistant
___ Sunlight resistant
___ Other
❑ Documentation
___ Certificates of Compliance
___ Certified Test Reports
___ Drawings
___ Warranties
___ Other
❑ System Characteristics
❑ Shipping Details
___ Cut lengths
___ Installation recommendation
___ Lagging
___ Returnable reels
___ Other
❑ Identification
___ Cable
___ Circuit
___ Reel

Note: This checklist must be accompanied by exact system details about the environment and electrical characteristics.

Metric Conversion

	To Convert From	To	Multiply By
Length	Inches	Millimeters	25.4
	Millimeters	Inches	0.03937
	Inches	Centimeters	2.54
	Centimeters	Inches	0.3937
	Feet	Meters	0.3048
	Meters	Feet	3.2808
	Kilofeet (1000 ft)	Kilometers	0.3048
	Kilometers	Kilofeet (1000 ft)	3.2808
Area	Square Inches	Square Millimeters	645.16
	Square Millimeters	Square Inches	0.00155
	Square Inches	Square Centimeters	6.4516
	Square Centimeters	Square Inches	0.155
	Square Inches	Circular Mils	1,273,240
	Circular Mils	Square Inches	7.854×10^{-7}
	Circular Mils	Square Millimeters	5.066×10^{4}
	Square Millimeters	Circular Mils	1973.51
	Square Feet	Square Meters	0.0929
	Square Meters	Square Feet	10.764
Weight	Pounds	Kilograms	0.4536
	Kilograms	Pounds	2.2046
	Pound/Kilofeet	Kilograms/Kilometer	1.4882
	Kilograms/Kilometer	Pounds/Kilofeet	0.6720
Electrical	Ohms/Kilofeet	Ohms/Kilometer	3.2808
	Ohms/Kilometer	Ohms/Kilofeet	0.3048
	Microfarads/Kilofeet	Microfarads/Kilometer	3.2808
	Microfarads/Kilometer	Microfarads/Kilofeet	0.3048
	Insulation Resistance:		
	Megohms—Kilofeet	Megohms—Kilometer	0.3048
	Megohms—Kilometer	Megohms—Kilofeet	3.2808
Mechanical	Pounds/Square Inch	Kilo Pascal*	6.895
	Kilo Pascal*	Pounds/Square Inch	0.1432
	Pounds (force)	Newtons	4.448
	Newtons	Pounds (force)	0.2248

* 1 Pascal = 1 newton/m^2

Common Color Sequence

Table E1 Color Sequence

COND NO.	BACKGROUND OR BASE COLOR	FIRST TRACER COLOR	SECOND TRACER COLOR	COND NO.	BACKGROUND OR BASE COLOR	FIRST TRACER COLOR	SECOND TRACER COLOR
1	Black	-	-	20	Red	Green	-
2	White	-	-	21	Orange	Green	-
3	Red	-	-	22	Black	White	Red
4	Green	-	-	23	White	Black	Red
5	Orange	-	-	24	Red	Black	White
6	Blue	-	-	25	Green	Black	White
7	White	Black	-	26	Orange	Black	White
8	Red	Black	-	27	Blue	Black	White
9	Green	Black	-	28	Black	Red	Green
10	Orange	Black	-	29	White	Red	Green
11	Blue	Black	-	30	Red	Black	Green
12	Black	White	-	31	Green	Black	Orange
13	Red	White	-	32	Orange	Black	Green
14	Green	White	-	33	Blue	White	Orange
15	Blue	White	-	34	Black	White	Orange
16	Black	Red	-	35	White	Red	Orange
17	White	Red	-	36	Orange	White	Blue
18	Orange	Red	-	37	White	Red	Blue
19	Blue	Red	-				

Pair cables are Black, White and numbered. Triad cables are Black, White, Red and numbered.

Table E2 Color Sequence

COND NO.	BACKGROUND OR BASE COLOR	TRACER COLOR	COND NO.	BACKGROUND OR BASE COLOR	TRACER COLOR
1	Black	-	19	Orange	Blue
2	Red	-	20	Yellow	Blue
3	Blue	-	21	Brown	Blue
4	Orange	-	22	Black	Orange
5	Yellow	-	23	Red	Orange
6	Brown	-	24	Blue	Orange
7	Red	Black	25	Yellow	Orange
8	Blue	Black	26	Brown	Orange
9	Orange	Black	27	Black	Yellow
10	Yellow	Black	28	Red	Yellow
11	Brown	Black	29	Blue	Yellow
12	Black	Red	30	Orange	Yellow
13	Blue	Red	31	Brown	Yellow
14	Orange	Red	32	Black	Brown
15	Yellow	Red	33	Red	Brown
16	Brown	Red	34	Blue	Brown
17	Black	Blue	35	Orange	Brown
18	Red	Blue	36	Yellow	Brown

Pair cables are Black, Red and numbered. Triad cables are Black, Red, Blue and numbered. Colors repeat after 36 conductors. There are no Green or White conductors or stripes.

Method 4 - All conductors black

COND.	CONDUCTOR PRINTING
1st	“1-One”
2nd	“2-Two”
3rd	“3-Three”
4th	“4-Four”
5th	“5-Five”

Jacket & Insulation Materials

Thermoplastic Properties

INSULATION OR JACKET MATERIAL	CHLORINATED POLYETHYLENE (CPE)	POLYVINYL CHLORIDE (PVC)	LOW DENSITY POLYETHYLENE	CELLULAR POLYETHYLENE	HIGH DENSITY POLYETHYLENE	POLY-URETHANE	POLY-PROPYLENE	NYLON	TEFLON	TPE
Oxidation Resistance	E	E	E	E	E	E	E	E	0	E
Heat Resistance	G-E	G-E	G	G-E	E	E	G	E	0	G
Oil Resistance	E	E	G-E	G-E	G-E	E	E	E	0	P
Low Temp. Flexibility	G	P-G	G-E	E	E	E	G	G	0	E
Weather, Sun Resistance	E	G-E	E	E	E	E	F-G	E	0	—
Ozone Resistance	E	E	E	E	E	E	E	E	E	E
Abrasion Resistance	E	F-G	F-G	G	E	F-G	0	E	G-E	F
Electrical Properties	F	F-G	E	E	E	E	P-F	F	E	G
Flame Resistance	F	E	P	P	P	P	P	P	0	F
Nuclear Radiation Resistance	G-E	P-F	G	G	G	F	G	F-G	P-F	F
Water Resistance	G	E	E	E	E	E	P	P-F	E	E
Acid Resistance	G-E	G-E	G-E	G-E	G-E	E	F	P-F	E	G
Alkali Resistance	G-E	G-E	G-E	G-E	G-E	E	F	E	E	G
Gasoline, Kerosene, Etc. (Alaphatic Hydrocarbons Resistance)	F	G-E	P-F	P-F	P-F	P-F	F	G	E	P
Benzol, Toluol Etc. (Aromatic Hydrocarbons Resistance)	F	P-F	P	P	P	P-F	P	G	E	P
Degreaser Solvents (Halogenated Hydrocarbons) Resistance	P	P-F	P	P	P	P	P	G	E	P
Alcohol Resistance	G	G-E	E	E	E	E	P	P	E	E

P = Poor
F = Fair
G = Good
E = Excellent
O = Outstanding

Any given property can usually be improved by the use of selective compounding.
Dimensions and weights are nominal; subject to industry tolerance.

Jacket & Insulation Materials

Thermoset Properties

INSULATION OR JACKET MATERIAL	STYRENE BUTADIENE RUBBER (SBR)	NATURAL RUBBER	SYNTHETIC RUBBER	POLY BUTADIENE	NEOPRENE	HYPALON® CHLORO-SULFONATED POLYETHELENE (CSPE)	NITRILE OR RUBBER BUTADINE NITRILE (NBR)	NITRILE/ POLY-CHLORIDE (NBR/PVC)	ETHYLENE PROPYLENE RUBBER (EPR)	CROSS-LINKED POLYETHYLENE (XLPE)	CHLORINATE POLYETHYLENE (CPE)	SILICONE RUBBER
Oxidation Resistance	F	F	G	G	G	E	F	E	G	E	E	E
Heat Resistance	F-G	F	F	F	G	E	G	G	E	G	E	G
Oil Resistance	P	P	P	P	G	G	G-E	G	F	G	G-E	F-G
Low Temp. Flexibility	F-G	G	E	E	F-G	F	F	F	G-E	0	F	0
Weather, Sun Resistance	F	F	F	F	G	E	F-G	G	E	G	E	0
Ozone Resistance	P	P	P	P	G	E	P	G	E	E	G-E	0
Abrasion Resistance	G-E	E	E	E	G-E	G	G-E	E	G	F-G	G-E	F
Electrical Properties	E	E	E	E	F	G	P	F	E	E	F-G	0
Flame Resistance	P	P	P	P	G	G	P	G	P	F-G	G	F-G
Nuclear Radiation Resistance	F-G	F-G	F-G	P	F-G	G	F-G	P	G	E	G	E
Water Resistance	G-E	G-E	E	E	G	G-E	G-E	E	G-E	G-E	G-E	G-E
Acid Resistance	F-G	F-G	F-G	F-G	G	E	G	G	G-E	G-E	E	F-G
Alkali Resistance	F-G	F-G	F-G	F-G	G	E	F-G	G	G-E	G-E	E	F-G
Gasoline, Kerosene, Etc. (Alaphatic Hydrocarbons Resistance)	P	P	P	P	G	F	E	G-E	P	F	F	P-F
Benzol, Toluol Etc. (Aromatic Hydrocarbons Resistance)	P	P	P	P	P-F	F	G	G	F	F	F	P
Degreaser Solvents (Halogenated Hydrocarbons) Resistance	P	P	P	P	P	P-F	P	G	P	F	P	P-G
Alcohol Resistance	F	G	G	F-G	F	G	E	G	P	E	G-E	G

P = Poor
F = Fair
G = Good
E = Excellent
O = Outstanding

Any given property can usually be improved by the use of selective compounding.
Dimensions and weights are nominal; subject to industry tolerance.

2002 NEC Chapter 3 Article Conversion Chart

2002 NEC Chapter 3 Article Conversion Chart

1999 ARTICLE NUMBER	ARTICLE TITLE	2002 ARTICLE NUMBER
300	WIRING METHODS	300
305	TEMPORARY WIRING	527
310	CONDUCTORS FOR GENERAL WIRING	310
318	CABLE TRAYS	392
320	OPEN WIRING ON INSULATORS	398
321	MESSENGER SUPPORTED WIRING	396
324	CONCEALED KNOB-AND-TUBE WIRING	394
325	INTEGRATED GAS SPACER CABLE	326
326	MEDIUM VOLTAGE CABLE	328
328	FLAT CONDUCTOR CABLE	324
330	MINERAL-INSULATED, METAL-SHEATHED CABLE	332
331	ELECTRICAL NONMETALLIC TUBING	362
333	ARMORED CABLE	320
334	METAL-CLAD CABLE	330
336	NONMETALLIC-SHEATHED CABLE	334
338	SERVICE-ENTRANCE CABLE	338
339	UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE	340
340	POWER AND CONTROL TRAY CABLE	336
342	NONMETALLIC EXTENSIONS	382
343	NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS	354
345	INTERMEDIATE METAL CONDUIT	342
346	RIGID METAL CONDUIT	344
347	RIGID NONMETALLIC CONDUIT	352
348	ELECTRICAL METALLIC TUBING	358
349	FLEXIBLE METALLIC TUBING	360
350	FLEXIBLE METAL CONDUIT	348
351A	LIQUIDTIGHT FLEXIBLE METAL CONDUIT	350
351B	LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT	356
352A	SURFACE METAL RACEWAYS	386
352B	SURFACE NONMETALLIC RACEWAYS	388
352C	STRUT-TYPE CHANNEL RACEWAY	384
353	MULTIOUTLET ASSEMBLY	380
354	UNDERFLOOR RACEWAYS	390
356	CELLULAR METAL FLOOR RACEWAYS	374
358	CELLULAR CONCRETE FLOOR RACEWAYS	372
362A	METAL WIREWAYS	376
362B	NONMETALLIC WIREWAYS	378
363	FLAT CABLE ASSEMBLIES	322
364	BUSWAYS	368
365	CABLEBUS	370
370	OUTLET, DEVICE, PULL AND JUNCTION BOXES, CONDUIT BODIES AND FITTINGS	314
373	CABINETS, CUTOUT BOXES, AND METER SOCKET ENCLOSURES	312
374	AUXILIARY GUTTERS	366
380	SWITCHES	404
384	SWITCHBOARDS AND PANELBOARDS	408
N/A	RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)	406

NEC & CSA Designations

NEC WIRE TYPE	DESCRIPTION
AWM	Appliance Wiring Material, Thermoplastic Insulation (PVC), With or Without Nylon, 105˚C, Dry Locations
MV-HL	Suffix “-HL” Indicates Acceptable for Hazardous Locations
ITC	Instrumentation Tray Cable, Several Combinations for Insulations & Jacket Compounds
MV-LS	Suffix “-LS” Indicates Acceptable for Limited Smoke Applications
MC	Metal Clad Cable, THHN or XHHW Individual Conductors, Aluminum or Steel Interlocked Armor
MTW	Machine Tool Wire, Thermoplastic Insulation (PVC), With or Without Nylon, 90˚C, Dry Locations
MV-90	Medium Voltage Cable Rated at 90˚C
MV-105	Medium Voltage Cable Rated at 105˚C
PLTC	Power-Limited Tray Cable, Several Combinations of Insulations & Jacket Compounds
RHH	Rubber Equivalent Insulation (XLPE), High Heat Resistant 90˚C Rating, Dry or Damp Locations
RHW-2	Rubber Equivalent Insulation (XLPE), Heat Resistant 90˚C Rating, Wet Locations
SF-2	Silicone Insulated Fixture Wire, Solid or 2 Strand
SFF-2	Silicone Insulated Fixture Wire, Flexible Strand
SIS	Flame Retardant Thermoset Switchboard Wire
TC	Tray Cable, Several Combinations of Insulation and Jacket Compounds, Cable Tray Use
TFFN	Thermoplastic Insulation (PVC), Flexible Fixture Wire, 90˚C, Dry Locations, Nylon Jacket
TFN	Thermoplastic Insulation (PVC), Fixture Wire, 90˚C, Dry Locations, Nylon Jacket
THHN	Thermoplastic Insulation (PVC), HighHeat Resistant, 90˚C Rating, Dry or Damp Locations, Nylon Jacket
THWN	Thermoplastic Insulation (PVC), Heat Resistant 75˚C Rating, Wet Locations, Nylon Jacket
USE-2	Underground Service Entrance, Cross-Linked Polyethylene Insulation (XLPE), Direct Burial, 90˚C Rating
XHHW-2	Cross-Linked Polyethylene Insulation (XLPE), High Heat Resistant 90˚C Rating, Wet and Dry Locations

CSA WIRE TYPE	DESCRIPTION
AC90	600 Volt XLPE insulation Aluminum or Steel Interlocked Armored Cable
ACIC	300 or 600 Volt Armored Instrument and Control Cable. A CSA type designation used to describe Armored Instrumentation and Control Cable. Available in either 300 Volt or 600 Volt with thermoset or thermoplastic insulation, this cable can be supplied with an overall shield, shielded pairs, shielded triads or unshielded in multi-conductor constructions from 2 to 72 conductors. The overall interlocked armor and PVC jacket provide a (-40˚C), HL, FT4 product (CSA reference standard C22.2 No. 239)
ACWU90 (-40˚C)	600 Volt XLPE insulation Aluminum or Steel Interlocked Armored Cable with PVC jacket
HL (Hazardous Locations)	Designation for hazardous locations (CSA STD C22.2 NO174)
NMD90	300 Volt Non-Metallic Sheath Cable with XLPE or PVC/Nylon insulation
NMWU	300 Volt Non-Metallic Sheath Cable with PVC insulation
RA90 (-40˚C)	600 and 5000 Volt single &multiple conductor with seamless corrugated aluminum armor. A CSA type designation for single conductor or multi-conductor constructions similar to AC90 and ACWU90 except no bonding (grounding) conductor is required in the cable assembly. Also the armor is a corrugated aluminum sheath which serves as a bonding (grounding) conductor. The overall PVCcovering on RA90 is required for wet or direct burial applications (CSA reference standard C22.2 No. 123)
RW90 XLPE (-40˚C)	600 and 5000 Volt thermoset insulation 90˚C wet or dry locations
RWU90 XLPE (-40˚C)	600 and 1000 Volt thermoset insulation 90˚C direct burial
SEW-2	600 Volt silicon rubber insulated equipment wire solid or 7 strand
SEWF-2	600 Volt silicone rubber insulated equipment wire with flexible strand
TECK90 (-40˚C)	600 and 5000 Volt single & multiple conductor cable with inner jacket, Aluminum or Steel Interlocked Armor with PVC jacket
TC	Tray cable certified for use in class 1 Division 2 areas
TW75	600 Volt Thermoplastic (PVC) Insulated Cable suitable for wet locations
TWU (-40˚C)	600 Volt Thermoplastic (PVC) Insulated Cable suitable for direct burial

Conductor Reference Table

TABLE 1 – Conductor Reference Table – Stranded Bare Copper Conductor and Aluminum (ACM) Conductor

Stranded Bare Copper Conductor Standards

Conforms to:
- ASTM B3 Soft or annealed copper wire
- ASTM B8 Concentric lay stranded copper conductors Class B, C & D
- ASTM B33 Tinned soft or annealed copper wire
- ASTM B172 Rope lay stranded copper conductors having bunch stranded members Classes I, K & M
- ASTM B173 Rope lay stranded copper conductors having concentric stranded members Classes G & H
- ASTM B174 Bunch stranded copper conductors
- ASTM B496 Compact round concentric lay stranded copper conductors

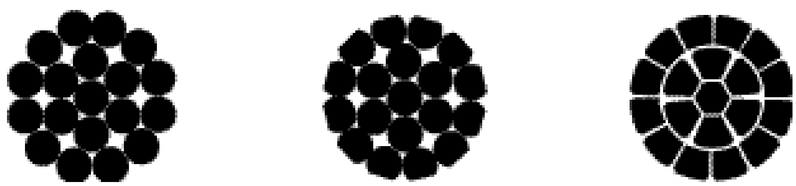
Stranded Aluminum (ACM) Conductor Standards

Conforms to:
- ASTM B 800 for 8000 Series Aluminum Alloy Wire
- ASTM B 801 for Concentric-Lay-Stranding (including Compressed)

Stranding: 6 AWG 1000 kcmil: Compressed

Concentric Stranding

Round 100% **Compressed 97%** **Compact 90%**



(Diameters and Cable Weights listed below are nominal)

CONDUCTOR SIZE AWG OR kcmil	CROSS SECTIONAL AREA cmil	NUMBER OF STRANDS	DIAMETER CONCENTRIC ROUND IN	mm	COMPRESSED IN	mm	COMPACT IN	mm	ALUMINUM (ACM) CONDUCTOR** CABLE WEIGHT LBS/1000FT	KG/KM
14	4,110	7	0.073	1.85	–	–	–	–	–	–
12	6,530	7	0.092	2.34	–	–	–	–	–	–
10	10,380	7	0.116	2.95	–	–	–	–	–	–
8	16,510	7	0.146	3.71	–	–	–	–	–	–
6	26,240	7	0.184	4.67	0.180	4.57	0.169	4.29	24	36
4	41,740	7	0.231	5.87	0.227	5.77	0.213	5.41	38	57
3	52,620	7	0.260	6.60	0.254	6.45	0.238	6.05	48	72
2	66,360	7	0.292	7.42	0.285	7.24	0.268	6.81	61	91
1	83,690	19*	0.331	8.41	0.321	8.15	0.299	7.59	77	115
1/0	105,600	19*	0.371	9.42	0.362	9.19	0.336	8.53	98	146
2/0	133,100	19*	0.415	10.54	0.406	10.31	0.376	9.55	123	183
3/0	167,800	19*	0.466	11.84	0.455	11.56	0.423	10.74	155	231
4/0	211,600	19*	0.523	13.28	0.513	13.03	0.475	12.07	196	291
250	250,000	37	0.570	14.48	0.558	14.17	0.520	13.21	233	346
300	300,000	37	0.624	15.85	0.610	15.49	0.574	14.58	279	415
350	350,000	37	0.674	17.12	0.662	16.81	0.616	15.65	325	484
400	400,000	37	0.721	18.31	0.706	17.93	0.663	16.84	372	553
450	450,000	37	0.764	19.41	0.745	18.92	0.705	17.91	418	622
500	500,000	37	0.806	20.47	0.790	20.07	0.736	18.69	465	692
600	600,000	61	0.884	22.45	0.865	21.97	0.813	20.65	558	830
750	750,000	61	0.990	25.15	0.970	24.64	0.908	23.06	697	1037
1000	1,000,000	61	1.143	29.03	1.130	28.70	1.060	26.92	929	1383

* For Compact Conductors 18 Strands ** Compressed Stranding Dimensions and weights are nominal; subject to industry tolerance.

Conductors for General Wiring

Copper Conductor

		ASTM CLASS B					
SIZE AWG/kcmil	STRANDING #/STRAND DIAMETER (INCH)	NOMINAL AREA kcmil	NOMINAL AREA mm²	NOMINAL DIAMETER INCHES	NOMINAL DIAMETER mm	NOMINAL WEIGHT LBS/KFT	NOMINAL WEIGHT KG/KM
22	7/.0100	0.64	0.32	0.030	0.76	2.2	3.3
20	7/.0121	1.02	0.52	0.036	0.91	3.2	4.8
18	7/.0152	1.62	0.82	0.045	1.14	5.0	7.4
16	7/.0192	2.58	1.31	0.056	1.42	8.0	12
14	7/.0242	4.11	2.08	0.071	1.80	12.7	18.9
12	7/.0305	6.53	3.31	0.090	2.29	20.2	30.1
10	7/.0385	10.38	5.26	0.113	2.87	32.1	47.8
9	7/.0432	13.09	6.63	0.127	3.23	40.4	60.1
8	7/.0486	16.51	8.37	0.143	3.63	51.0	74.4
7	7/.0545	20.82	10.5	0.160	4.06	64.3	95.7
6	7/.0612	26.24	13.3	0.180	4.57	81.1	121
5	7/.0688	33.09	16.8	0.202	5.13	102	152
4	7/.0772	41.74	21.2	0.227	5.77	129	192
3	7/.0867	52.62	26.7	0.255	6.48	163	243
2	7/.0974	66.36	33.6	0.286	7.26	205	305
1	19/.0664	83.69	42.4	0.324	8.23	258	384
1/0	19/.0745	105.6	53.5	0.363	9.22	326	485
2/0	19/.0837	133.1	67.4	0.408	10.4	411	612
3/0	19/.0940	167.8	85.0	0.458	11.6	518	771
4/0	19/.1055	211.6	107	0.514	13.1	653	972
250	37/.0822	250	127	0.561	14.2	772	1150
262.6	-	-	-	-	-	-	-
300	37/.0900	300	152	0.614	15.6	926	1380
313.1	-	-	-	-	-	-	-
350	37/.0973	350	177	0.664	16.9	1080	1607
373.7	-	-	-	-	-	-	-
400	37/.1040	400	203	0.710	18.0	1235	1838
444.4	-	-	-	-	-	-	-
500	37/.1162	500	253	0.793	20.1	1544	2297
535.3	-	-	-	-	-	-	-
592	-	-	-	-	-	-	-
600	61/.0992	600	304	0.871	22.1	1853	2757
646.4	-	-	-	-	-	-	-
750	61/.1109	750	380	0.973	24.7	2316	3446
777.7	-	-	-	-	-	-	-
1000	61/.1280	1000	507	1.123	28.5	3088	4595
1111	-	-	-	-	-	-	-

Dimensions and weights are nominal; subject to industry tolerance.

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Conductors for General Wiring

Copper Conductor

SIZE AWG/kcmil	STRANDING #/STRAND DIAMETER (INCH)	ASTM CLASS C NOMINAL AREA kcmil	NOMINAL AREA mm^2	NOMINAL DIAMETER INCHES	NOMINAL DIAMETER mm	NOMINAL WEIGHT LBS/KFT	NOMINAL WEIGHT KG/KM
22	19/.0063	0.64	0.32	0.031	0.79	2.3	3.4
20	19/.0080	1.02	0.52	0.038	0.97	3.8	5.7
18	19/.0092	1.62	0.82	0.044	1.12	5.0	7.4
16	19/.0117	2.58	1.31	0.056	1.42	8.0	12
14	19/.0147	4.11	2.08	0.071	1.80	12.7	18.9
12	19/.0185	6.53	3.31	0.089	2.26	20.2	30.1
10	19/.0234	10.38	5.26	0.112	2.85	32.1	47.8
9	19/.0262	13.09	6.63	0.123	3.12	40.4	60.1
8	19/.0295	16.51	8.37	0.139	3.53	51.0	74.4
7	19/.0331	20.82	10.5	0.156	3.96	64.3	95.7
6	19/.0372	26.24	13.3	0.175	4.45	81.0	121
5	19/.0417	33.09	16.8	0.203	5.16	102	152
4	19/.0469	41.74	21.2	0.229	5.82	129	192
3	19/.0526	52.62	26.7	0.256	6.50	163	243
2	19/.0591	66.36	33.6	0.288	7.32	205	305
1	37/.0476	83.69	42.4	0.325	8.26	258	384
1/0	37/.0534	105.6	53.5	0.364	9.25	326	485
2/0	37/.0600	133.1	67.4	0.410	10.4	411	612
3/0	37/.0673	167.8	85.0	0.459	11.7	518	771
4/0	37/.0756	211.6	107	0.516	13.1	653	972
250	61/.0640	250	127	0.562	14.3	774	1150
262.6	-	-	-	-	-	-	-
300	61/.0701	300	152	0.615	15.6	927	1380
313.1	-	-	-	-	-	-	-
350	61/.0757	350	177	0.664	16.9	1082	1610
373.7	-	-	-	-	-	-	-
400	61/.0810	400	203	0.711	18.1	1235	1838
444.4	-	-	-	-	-	-	-
500	61/.0905	500	253	0.794	20.2	1545	2299
535.3	-	-	-	-	-	-	-
592	-	-	-	-	-	-	-
600	91/.0812	600	304	0.893	22.7	1853	2757
646.4	-	-	-	-	-	-	-
750	91/.0908	750	380	0.999	25.4	2316	3446
777.7	-	-	-	-	-	-	-
1000	91/.1048	1000	507	1.153	29.3	3088	4595
1111	-	-	-	-	-	-	

Dimensions and weights are nominal; subject to industry tolerance.

Conductors for General Wiring

Copper Conductor

SIZE AWG/kcmil	STRANDING #/STRAND DIAMETER (INCH)	ASTM CLASS H NOMINAL AREA kcmil	NOMINAL AREA mm²	NOMINAL DIAMETER INCHES	NOMINAL DIAMETER mm	NOMINAL WEIGHT LBS/KFT	NOMINAL WEIGHT KG/KM
22	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
8	133/.0111	16.51	8.37	0.164	4.17	52	77
7	133/.0126	20.82	10.5	0.190	4.83	67	100
6	133/.0140	26.24	13.3	0.204	5.18	82	122
5	133/.0158	33.09	16.8	0.231	5.87	105	156
4	133/.0177	41.74	21.2	0.260	6.60	132	196
3	133/.0199	52.62	26.7	0.292	7.42	167	248
2	133/.0223	66.36	33.6	0.327	8.31	208	310
1	259/.0180	83.69	42.4	0.363	9.22	266	396
1/0	259/.0202	105.6	53.5	0.407	10.3	334	497
2/0	259/.0227	133.1	67.4	0.458	11.6	422	628
3/0	259/.0255	167.8	85.0	0.515	13.1	533	793
4/0	259/.0286	211.6	107	0.579	14.7	670	997
250	427/.0242	250	127	0.627	15.9	795	1183
262.6	-	-	-	-	-	-	-
300	427/.0265	300	152	0.702	17.8	953	1418
313.1	-	-	-	-	-	-	-
350	427/.0286	350	177	0.740	18.8	1110	1652
373.7	-	-	-	-	-	-	-
400	427/.0306	400	203	0.809	20.5	1270	1890
444.4	-	-	-	-	-	-	-
500	427/.0342	500	253	0.900	22.9	1590	2366
535.3	-	-	-	-	-	-	-
592	-	-	-	-	-	-	-
600	703/.0292	600	304	1.022	26.0	1920	2857
646.4	-	-	-	-	-	-	-
750	703/.0327	750	380	1.122	28.5	2410	3586
777.7	-	-	-	-	-	-	-
1000	703/.0377	1000	507	1.294	32.9	3205	4769
1111	-	-	-	-	-	-	-

Dimensions and weights are nominal; subject to industry tolerance.

Conductors for General Wiring

Copper Conductor

		CLASS I TYPE					
SIZE AWG/kcmil	STRANDING #/STRAND DIAMETER (INCH)	NOMINAL AREA kcmil	mm²	NOMINAL DIAMETER INCHES	mm	NOMINAL WEIGHT LBS/KFT	KG/KM
22	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
10	27/24	10.91	5.53	0.123	3.12	33.7	50
9	-	-	-	-	-	-	-
8	37/24	14.95	7.57	0.138	3.50	46.0	68
7	-	-	-	-	-	-	-
6	61/24	24.64	12.5	0.190	4.83	77	114
5	91/24	36.76	19	0.240	6.10	113	168
4	105/24	42.42	21	0.260	6.60	132	196
3	125/24	50.5	25	0.285	7.24	155	231
2	150/24	60.6	31	0.320	8.13	189	281
1	225/24	90.9	46	0.385	9.78	280	417
1/0	275/24	111.1	56	0.435	11.0	346	515
2/0	325/24	131.3	66	0.470	11.9	403	600
3/0	450/24	181.8	92	0.545	13.8	567	844
4/0	550/24	222.2	112	0.580	14.7	684	1018
250	-	-	-	-	-	-	-
262.6	650/24	262.6	133	0.652	16	820	1220
300	-	-	-	-	-	-	-
313.1	775/24	313.1	159	0.700	18	960	1428
350	-	-	-	-	-	-	-
373.7	925/24	373.7	189	0.760	19	1105	1644
400	-	-	-	-	-	-	-
444.4	1100/24	444.4	225	0.850	21	1370	2038
500	-	-	-	-	-	-	-
535.3	1325/24	535.3	271	0.940	24	1700	2530
592	1480/24	597.9	303	0.970	25	1835	2730
600	-	-	-	-	-	-	-
646.4	1600/24	646.4	327	1.040	26	1992	2964
750	-	-	-	-	-	-	-
777.7	1925/24	777.7	394	1.120	28	2390	3556
1000	-	-	-	-	-	-	-
1111	2750/24	1111	563	1.340	34	3400	5059

Dimensions and weights are nominal; subject to industry tolerance.

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Conductors for General Wiring

Copper Conductor

SIZE AWG/kcmil	STRANDING #/STRAND DIAMETER (INCH)	ASTM CLASS K NOMINAL AREA kcmil	NOMINAL AREA mm²	NOMINAL DIAMETER INCHES	NOMINAL DIAMETER mm	NOMINAL WEIGHT LBS/KFT	NOMINAL WEIGHT KG/KM
22	-	-	-	-	-	-	-
20	10/.010	1.02	0.52	0.036	0.91	3.2	4.8
18	16/.010	1.62	0.82	0.046	1.2	5.0	7.4
16	26/.010	2.58	1.31	0.057	1.4	7.8	12
14	41/.010	4.11	2.08	0.071	1.8	12.8	19.0
12	65/.010	6.53	3.31	0.088	2.2	20.3	30.2
10	105/.010	10.38	5.26	0.112	2.8	33.3	49.6
9	133/.010	13.09	6.63	0.150	3.8	42.4	63.1
8	168/.010	16.51	8.37	0.158	4.0	54.3	80.8
7	210/.010	20.82	10.5	0.175	4.4	66.8	99.4
6	266/.010	26.24	13.3	0.198	5.0	84.2	125
5	336/.010	33.09	16.8	0.261	6.6	106	158
4	420/.010	41.74	21.2	0.249	6.3	132	196
3	532/.010	52.62	26.7	0.298	7.6	169	251
2	665/.010	66.36	33.6	0.317	8.1	211	314
1	836/.010	83.69	42.4	0.356	9.0	266	396
1/0	1064/.010	105.6	53.5	0.401	10	338	503
2/0	1323/.010	133.1	67.4	0.501	13	425	632
3/0	1666/.010	167.8	85.0	0.562	14	535	796
4/0	2107/.010	211.6	107	0.632	16	676	1006
250	2499/.010	250	127	0.688	17	802	1193
262.6	2220/.010	222	112	0.680	17	850	1265
300	2989/.010	300	152	0.753	19	960	1428
313.1	3136/.010	313.6	159	0.750	19	969	1442
350	3458/.010	350	177	0.818	21	1120	1667
373.7	3737/.010	373.7	189	0.790	20	1210	1800
400	3990/.010	400	203	0.878	22	1290	1920
444.4	-	-	-	-	-	-	-
500	5054/.010	500	253	0.990	25	1635	2433
535.3	5320/.010	532	270	0.950	24	1641	2442
592	-	-	-	-	-	-	-
600	5985/.010	600	304	1.125	29	1950	2902
646.4	6466/.010	646.6	328	1.040	26	1987	2957
750	7448/.010	750	380	1.276	32	2427	3611
777.7	-	-	-	-	-	-	-
1000	9975/.010	1000	507	1.498	38	3250	4769
1111	-	-	-	-	-	-	

Dimensions and weights are nominal; subject to industry tolerance.

Recommended Handling and Storage Practices

Unloading and Moving of Reels:

Cable reels are never shipped upended (flat side down). Cable reels that arrive in this manner should be rejected or received only after a thorough inspection for damage.

See Page 162, “How To Handle Cable Reels”.

Upon receipt, a cable’s protective covering and/or lagging should be inspected for evidence of damage during shipment. If evidence of damage is found, a report should immediately be made to the carrier.

Under no circumstances should reels be dropped from the delivering vehicle to the ground.

Unloading and reel handling should be accomplished so that the equipment used does not contact the cable surface, and in the case of protective wrap that the equipment does not contact the protective wrap.

If unloading and reel handling is accomplished by crane, either a cradle supporting the reel flanges or a shaft through the arbor hole should be used. If a fork lift is utilized, the forks must lift the reel at 90˚ to the flanges and the forks must be long enough to make complete lifting contact with both flanges. Under no circumstances should the forks come into contact with the cable surface or the protective wraps.

When a reel of cable is rolled from one point to another, care must be taken to see that there are no objects on the surface area which could contact or damage the cable surface or protective wrap.

If an inclined ramp is used for unloading, the ramp must be wide enough to contact both flanges completely. The stopping of the reels at the bottom shall be accomplished by using the reel flanges and not the surface of the cable.

Storage and Storage Maintenance:

Finished cables have no established shelf-life. Moisture and atmospheric conditions can cause exposed conductors to oxidize and discolor. Uncovered/unsheltered cable will degrade due to exposure to direct sunlight and/or the elements. If the cables are protected there should be no degradation of the insulation.

In general any cable for use indoors should be stored indoors. Any cable suitable for installation outdoors is suitable for storage outdoors. Cables stored outdoors should have the ends sealed to prevent moisture ingress into the cable.

Cables should be stored in a sheltered area. While on the reel, cable should be covered with Masonite or a dark film wrap (to block the sun’s rays and shield from the elements).

Cables with a cold temperature marking i.e. –10˚C, –25˚C, or –40˚C may be stored outdoors. Cables without a cold temperature marking must be stored indoors.

Cable reels must remain in the upright position. Cable reels must not be stored on their sides. Reels must not be stacked.

Cable reels should be stored with the protective covering or lagging in place. If a length of cable has been cut from the reel, the cable end should be immediately resealed to prevent the entrance of moisture. If a part length is returned to storage, the reel’s protective covering should be restored.

Wooden reels should be stored off the ground to prevent rotting. Reels should be stored on a flat, hard surface so that flanges do not sink into the earth. The weight of the reel and cable must be carried at all times by the reel flanges.

Cable reels and lagging must not be stored for an extended time period sitting in direct contact with water or dampness. Timbers or metal supports must be placed under the reel flanges to provide elevated storage of the reels away from the direct contact with water or damp soil.

Recommended Handling and Storage Practices

Storage and Storage Maintenance: (continued)

Reels should be stored in an area where construction equipment, falling or flying objects or other materials will not contact the cable.

Cable should be stored in an area where chemicals or petroleum products will not be spilled or sprayed on the cable.

Cable should be stored in an area away from open fires or sources of high heat.

If the reels are relocated, they should be handled as suggested below and inspection made on each reel during the relocation.

If the cables are stored in a secure area and not exposed to the effects of the weather, an annual inspection should be satisfactory.

Where the reels are exposed to the weather, a bimonthly inspection should be performed to observe any sign of deterioration.

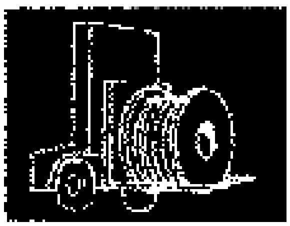
If the reels are exposed in a non-secure area, policing of the area at frequent intervals may be required depending on circumstances.

Records of delivery date, manufacturer, installation date, any extenuating circumstances, along with all test reports should be kept on file.

Recommended Handling and Storage Practices

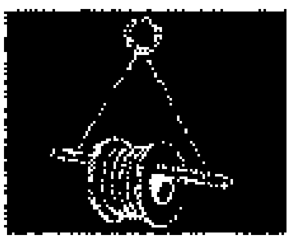
How to Handle Cable Reels

YES **NO**

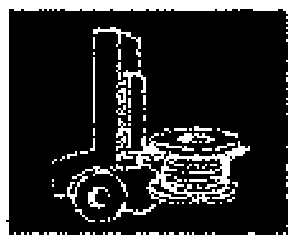


Cradle both reel flanges between forks.

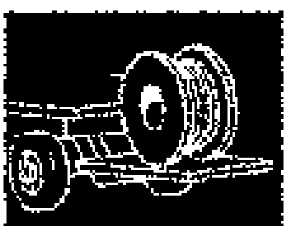
Upended heavy reels will often arrive damaged. Refuse or receive subject to inspection for hidden damage.



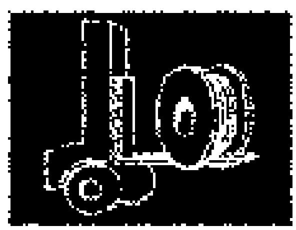
Reels can be hoisted with a shaft extending through both flanges.



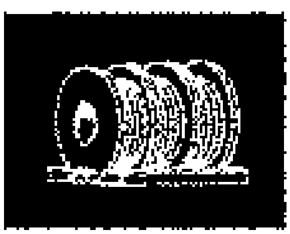
Do not lift by top flange. Cable or reel will be damaged.



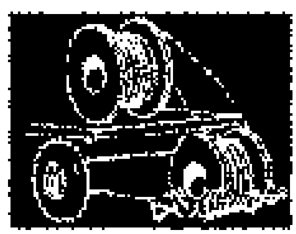
Lower reels from truck using hydraulic gate, hoist or fork lift. LOWERCARE-FULLY.



Never allow forks to touch cable surface or reel wrap.



Always load with flanges on edge and chock and block securely.



Never drop reels.

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Cable Pre-Installation

Pre-Installation

Overview

To ensure safety during cable installation and reliability once the cable is installed, you should confirm the following prior to installation:

- The cable selected is proper for your application
- The cable has not been damaged in transit or storage

Review all applicable state and national codes to verify that the cable chosen is appropriate for the job. Also, consult your local building authority.

Next, you must identify any existing cable damage and prevent any further damage from occurring. This is done through proper cable inspection, handling and storage.

Cable Inspection

Inspect every cable reel for damage before accepting the shipment. Be particularly alert for cable damage if:

- A reel is laying flat on its side
- Several reels are stacked
- Other freight is stacked on a reel
- Nails have been driven into reel flanges to secure shipping blocks
- A reel flange is damaged
- A cable covering is removed, stained or damaged
- A cable end seal is removed or damaged
- A reel has been dropped (hidden damage likely)

Cabling Handling

Remove all nails and staples from the reel flanges before moving a reel, and avoid all objects that could crush, gouge or impact the cable when moving. NEVER use the cable as a means to move a reel.

When unreeling, observe recommended bending radii, use swivels to prevent twisting and avoid overruns.

Cable Installation

Installation

Overview

A survey of customer complaints revealed that 92% of the cables in question failed due to mechanical damage. When does mechanical damage usually occur? During installation.

In fact, most cables are subjected to more mechanical stress during installation than they ever experience in actual operation. Needless to say, handling and pulling your cable according to manufacturer's recommendations is extremely important.

There are five main considerations in any cable installation:

- Ambient temperature
- Equipment
- Conduit fill
- Mechanical fit in raceway
- Physical limitations

These considerations were developed and refined by installers of paper-lead cables. Two excellent references are the "Underground Systems Reference Book" and "Pipeline Design for Pipe Type Feeders." The former was published by Edison Electric Institute in 1931 and was last revised in 1957. The latter was an AIEE paper (#53-389) by R.C. Rifenburg, published in Power Apparatus & Systems in December 1953.

Ambient Temperature

Low temperatures are a cause for concern when installing cable. The following are temperatures below which cable should not be installed.

- CSPE/EPR - 1/C..........................-31°F
- CPE Jacket.................................-31°F
- CPE/EPR - 1/C............................-31°F
- FREP, PE, XLPE - 1/C..................-58°F
- PVC...+14°F

CSPE = Chlorosulfonated Polyethylene (Hypalon®)

CPE = Chlorinated Polyethylene

EPR = Ethylene Propylene Rubber

PE = Polyethylene

FREP = Flame Retardant EP

PVC = Polyvinyl Chloride

XLPE = Cross-Linked Polyethylene

During cold weather installation, cable should be pulled more slowly and trained in place the same day it is removed from storage. Do not impact, drop, kink or bend cable sharply in low temperatures.

For additional information on cable installation, please refer to page 220 through 227.

Equipment

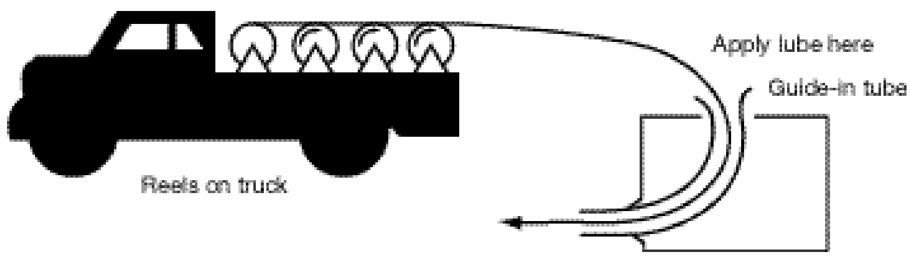
The proper use of appropriate equipment is crucial to a successful cable installation. The equipment needed for most installations is detailed in the following checklist:

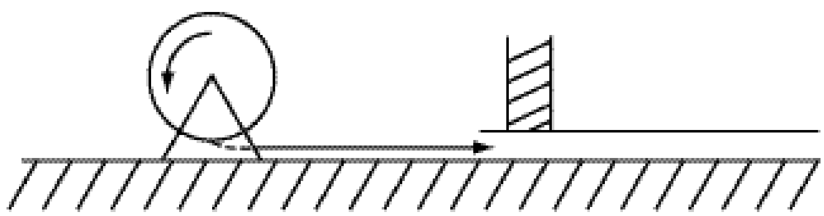
- ❑ Portable electric generator
- ❑ Extension cords & GFCI
- ❑ Pump, diaphragm
- ❑ Make-up air blower & hose
- ❑ Manhole cover hooks
- ❑ Warning flags, signs
- ❑ Electrostatic kV tester
- ❑ Electric safety blankets and clamps
- ❑ Radios or telephones
- ❑ Gloves
- ❑ Flood lamps
- ❑ Fishtape or string blower/vacuum
- ❑ Hand line
- ❑ Duct cleaning mandrels
- ❑ Duct testing mandrels
- ❑ Capstan type puller
- ❑ Snatch blocks
- ❑ Short ropes for temp tie-offs
- ❑ Guide-in flexible tubing (elephant trunks)
- ❑ Several wire rope slings of various lengths
- ❑ Shackles/clevis
- ❑ Gang rollers; with at least 4 ft. effective radius
- ❑ Hand winches (come-a-long)
- ❑ Manhole edge sheave
- ❑ Pulling rope
- ❑ Swivels
- ❑ Basket grip pullers
- ❑ 0-1/5/10 kip dynamometer
- ❑ Reel arbor
- ❑ Reel jacks
- ❑ Reel brakes
- ❑ Cable cutter
- ❑ Lint free rags
- ❑ Cable pulling lubricant
- ❑ Prelubing devices
- ❑ Plywood sheets
- ❑ Diameter tape
- ❑ 50 ft. measuring tape
- ❑ Silicone caulking (to seal cable ends)

Cable Installation

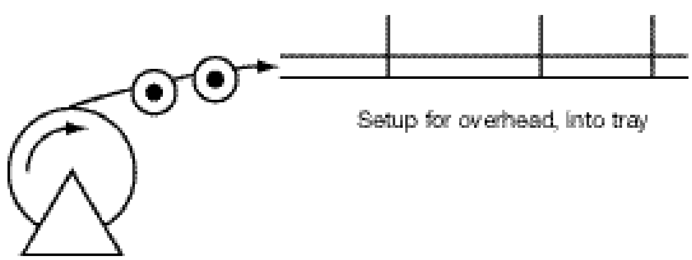
Cable Feed-In Setups

The following diagrams illustrate various cable feed-in setups:





Setup for duct close to floor



The feed-in setup should unreel the cable with a natural curvature (Figure 1) as opposed to a reverse "S" curvature (Figure 2).

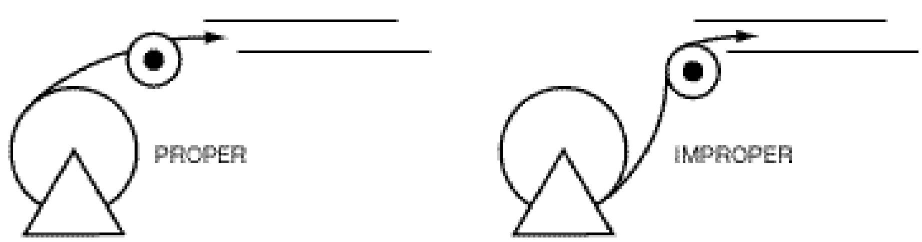
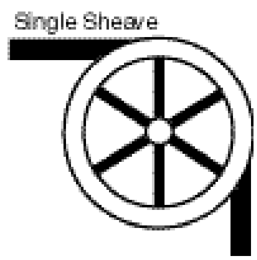


Figure 1 Figure 2

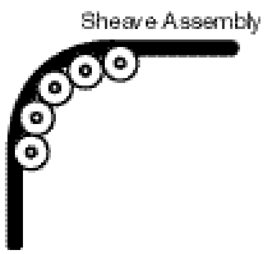
Cable Installation

Cable Feed-In Setups (continued)

Single Sheaves may be used only for GUIDING cables. Arrange multiple blocks to hold bending radii whenever cable is deflected.



For pulling around bends, use conveyor sheave assemblies of the appropriate radius series.



The pulleys must be positioned to ensure that the effective curvature is smooth and deflected evenly at each pulley. Never allow a polygon curvature to occur (Figure 3).

The fit of a pulley around the cable is also important when pulling heavy weights (i.e. pulleys at the top of a vertical drop).

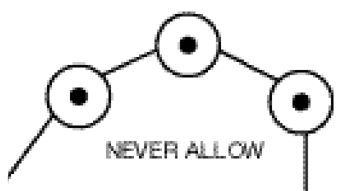
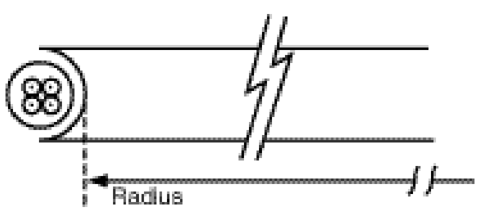


Figure 3

Remember to use the radius of the surface over which the cable is bent, not the outside flange diameter of the pulley. A “10 inch” cable sheave typically has an inside (bending) radius of 3 inches.



Cable Installation

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.

MAXIMUM ALLOWABLE CONDUCTOR TENSION (LBS)

	#CDR					
AWG/KCMIL	1	2	3	4	5	6
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

T = 0.008 x CM x N, if N ≤ 3.
T = 0.008 x CM x N x 0.8, if N > 3.

Dimensions and weights are nominal; subject to industry tolerance.

Cable Installation

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.

MAXIMUM ALLOWABLE CONDUCTOR TENSION (LBS)

	AWG							
	20	18	16	14	12	11	10	9
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	230	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 1000 lbs.
T = 0.008 x CM x N, if N ≤ 6.
T = 0.008 x CM x N x 0.8, if N > 6.
T = 0.008 x CM x N x 0.6, if twisted subassemblies.

Dimensions and weights are nominal; subject to industry tolerance.

Cable Installation

Physical Limitations
Training and Bending

Overview

Training is the positioning of cable which is not under tension. Bending is the positioning of cable which is under tension. When installing cable, the object is to limit these forces so that the cable's physical and electrical characteristics are maintained for the expected service life.

The recommended limits are:

- Tables per National Electric Code (see tables at right)
- Tables per ICEA/NEMA (see pg 100)
- A non-shielded cable can tolerate a sharper bend than a shielded cable can. This is especially true for cables having helical metal tapes which, when bent too sharply, can separate, buckle and cut into the insulation.

The problem is compounded by the fact that most tapes are under jackets which conceal such damage. The shielding bedding tapes or extruded polymers have sufficient conductivity and coverage initially to pass acceptance testing, then fail prematurely due to corona at the shield/insulation interface.

Remember that offsets are bends.

Applications in Accordance with the National Electrical Code.

TABLE 1
Shielded and Non-Armored
Single Conductor - 12 x Overall Diameter
Multiple Conductor - 12 x Diameter of the largest cable component over which the shield/lead cover is applied

TABLE 2
Non-Shielded and Non-Armored
Single and Multiple Conductor – 8 x Overall Diameter (Flexible Cable) 10 x Overall DIameter (Non-Flexible Cable)

TABLE 3
Armored Cable - Type MC
Interlocked or Continuously Seam Welded Corrugated Sheath
12 x External Diameter of Armor

In all cases, the minimum bending radius specified refers to the inner surface of the cable and not to the axis of the cable.

Cable Installation

Physical Limitations
Training and Bending (Continued)

Applications in Accordance With ICEA/NEMA STDS. (Non-Code)

TABLE I
Non-Shielded, Non-Armored Power & Control Cable

Thickness of Conductor Insulation (Inches)	Overall Diameter of Cable (Inches) Up to 1.000	1.001 To 2.000	Over 2.000
	Min. Bend Radius as a Multiple of Cable O.D.		
.155 and less	4	5	6
.170 to .310	5	6	7
.325 and Over	-	7	8

TABLE II
Metallic Shielded and/or Armored Power & Control Cable

Type of Cable	Min. Bend Radius as a Multiple of Cable O.D.
Flat Tape or Wire Armored	12
Armored, Interlocked (Duralox®)	12
Armored, Welded Corrugated Sheath (Philsheath®)	12
*Non-Armored, Tape Shielded (Uniblend®)	12
*Non-Armored, Wire Shielded or UniShield®	Table I Above

*Includes 12 x Single Conductor O.D. in Cabled Assemblies, i.e. Triplexed, Quadruplexed, etc.

The above Tables contain the minimum values for the radii to which insulated cables may be bent for permanent training during installation. These limits do not apply to conduit bends, sheaves or other curved surfaces around which the cable may be pulled under tension while being installed. Larger radii bends are required for such conditions due to the limitation of sidewall bearing pressure. In all cases the minimum radii specified refers to the inner surface of the cable and not to the axis of the cable.

Cable Installation

Maximum Sidewall Pressure

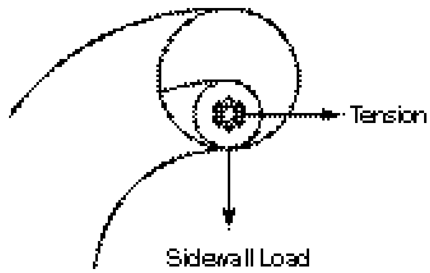
Sidewall Loading (Sidewall Bearing Pressure)

Overview

Sidewall load is the radial force exerted on a cable being pulled around a conduit bend or sheave. Excessive sidewall loading can crush a cable and is, therefore, one of the most restrictive factors in installations having bends or high tensions. Sidewall loading is reduced by increasing the radius of the bends.

The maximum tension that can be safely applied to the cable during installation can be derived using the maximum sidewall loading limit of the cable and the radius of the bend it is traversing.

For example, a cable having a maximum SWL of 300 lb/ft that is being pulled around a bend having a radius of 2 feet should have no greater than 300 lbs/ft x 2 ft or 600 lbs tension applied to it as the cable exits the bend. Laboratory tests conducted on standard cables after they had been subjected to conduit pull tests through 90° elbows of appropriate radii, indicate no significant change in the cable's electrical parameters at the following sidewall loads:



CABLE TYPE	SWL LBS/FT
600V non-shielded control	300
600V and 1kV non-shielded EP power	500
5 and 35kV UniShield® & Uniblend®, 5 kV Durasheath® EP	500
Interlocked and Philsheath® armored cable (All Voltage Classes)	300

General Cable's Approval List of Cable Pulling Lubricants

NAME OF LUBRICANT	MANUFACTURER
Polywater® A, G and J	American Polywater Corporation, Stillwater, MN
Polywater® Plus Silicone, Types NN, WNN, FS	American Polywater Corporation, Stillwater, MN
Wire Lube® Aqua-Gel®, Yellow 77*	Ideal Industries, Sycamore, IL
Dyna-Blue® Cable Lubricant	American Polywater Corporation, Stillwater, MN
Wirepull	Mac Products, Kearney, NJ

Other lubricants may be suitable for use with General Cable designs.
Contact the lubricant manufacturer about the compatibility of their products with specific cables.
Cable lubricants should be currently UL listed.
Contact lubricant manufacturers for proof of approval.
* Not recommended for our UniShield product line only.

Cable Testing

Prior to performing the "Hi-Pot" tests it is recommended that all insulated conductors should be meggered (insulation resistance tests) – See the formula below.

The test voltage should be increased in steps of 10kV, or minimum of 5 steps. The duration at each step should be long enough for the current to reach a steady value (1 minute suggested). The test current will momentarily increase for each voltage increment due to charging of the capacitance and the dielectric absorption characteristics of the insulation. Stabilized current should be recorded at each step.

The maximum test voltage should be maintained for 15 minutes (new cable, shielded) / 5 minutes (non-shielded). Leakage current should be recorded each minute after the maximum test voltage has been reached.

Increase of leakage current at any step point may be an indication of a cable insulation problem. Failure of the cable or cable accessories may result unless the voltage is rapidly reduced.

Otherwise, the leakage current should stabilize after about 5 minutes. Leakage current is essentially a function of the construction and length of cable but it can be influenced by the test conditions (wind and humidity) as well as the test apparatus (leads).

Typical leakage currents in the order of 100 – 150 microamperes are not unusual. A defective installation is identified by high or fluctuating leakage current with time, at a fixed DC voltage.

All testing should be performed by qualified personnel taking all appropriate safety precautions.

Insulation Resistance:
The value of insulation resistance at a temperature of 15.6˚C (60˚F), or when corrected to this temperature, shall not be less than the value of R calculated as follows:

$$R = K * \log_{10}\left(\frac{D}{d}\right)$$

Where:

R	=	insulation resistance (Megohms-kft)
K	=	insulation constant
D	=	diameter over insulation (in)
d	=	diameter under insulation (in)

Cable Testing

DC High Potential (HI-POT) Testing of Medium-Voltage Power Cables

Overview

This procedure is intended to provide general guidelines for high potential dc testing of power cables.

All tests made after cable installation and during the guarantee period shall be made in accordance with applicable specifications.

All safety precautions must be observed during testing at high voltage.

Read and understand and follow the Operator's Manual for the particular test set being used!

Test Equipment

Direct current test equipment is available commercially with a wide range of voltages. Accessory equipment is necessary to safely conduct high voltage tests such as safety barriers, rubber gloves and nonconducting hard hats must be used; consult appropriate safety officer.

Test Procedures

See IEEE Standard 400 (page 105). Acceptable procedures, although varying slightly in technique, have more or less been standardized as either a "withstand test" or a "time-leaking current test."

Before performing any dc overpotential tests:

- All equipment must be disconnected from the cable circuit, i.e. disconnect transformers, switch taps, motors, circuit breakers, surge arrestors, etc. This will preclude damage to such equipment and will prevent test interruptions due to flashovers and/or trip-outs resulting from excessive leakage current.
- Establish adequate clearance between the circuit test ends and any grounded object, and to other equipment not under test (about 2.5 feet).
- Ground all circuit conductors not under test with all cable shields including nearby equipment.
- Consult termination manufacturers for maximum test voltage recommendations and time limitations.

The direct current test voltage may be applied either continuously or in predetermined steps to the maximum value in accordance with applicable specifications.

- **Continuous Method –** Apply test voltage at an approximate rise rate of 1 kV per second or 75% of the rated current output of the equipment, whichever is less. Some equipment will take longer to reach the maximum test voltage because of the amount of charging current.
- **Step Method –** Apply test voltage slowly in 5 to 7 increments of equal value to the maximum specified. Allow sufficient time at each stop for the leakage current to stabilize.

HI-POT TESTING PROCEDURES

Normally this requires only a few seconds unless cable circuits of high capacitance are involved. Record leakage current at each step.

Maintain the test voltage at the prescribed value for the time designated in applicable specifications. The following times are usually considered adequate: at the end of the test period, set the test set voltage control to zero, allow the residual voltage on the circuit to decay, then ground the conductor just tested.

CAUTION

It should be recognized that dc charges on cable can build up to potentially dangerous levels if grounds are removed too quickly. Maintain solid grounds after the test on the cable for at least 4 times the duration of the test. On exceptionally long cable lengths it may be necessary to increase the grounding time. It is advantageous to maintain these grounds longer and while reconnecting circuit components.

- **Acceptance Testing –** After installation and before the cable is placed in regular service the specified test voltage shall be applied for **15 consecutive minutes.**
- **Proof Testing –** At any time during the period of guarantee the cable circuit may be removed from service and tested at a reduced voltage (normally 65 percent of the original acceptance value) for **5 consecutive minutes.**
- Record the leakage current, at one minute intervals for the duration of the test time involved.

Cable Testing

DC High Potential (HI-POT) Testing of Medium-Voltage Power Cables

Comments

DC overpotential testing of medium-voltage power cables is usually performed with negative polarity connected to the conductor.

DC overpotential testing is a tool only for determining insulation resistance at higher voltages. Effective insulation resistance of the cable system may be calculated by means of Ohms Law: R = V/I. The relation is:

$$\text{Megohms} = \frac{\text{Kilovolts} \times 1000}{\text{Microamperes}}$$

Insulation resistance may also be measured with standard instruments which give a direct reading at 500 volts (or higher, depending on the model). IR in general has little or no direct relationship to dielectric or breakdown strength.

The significance of conducting dc high-voltage tests on nonshielded, nonmetallic-sheathed cable is dependent upon the environment in which it is installed because the characteristics of the return circuits are unknown. The environment must be carefully considered or test results may not be significant. In fact, these tests can result in damage to the cable insulation.

Humidity, condensation and actual precipitation on the surface of a cable termination can increase the leakage current by several orders of magnitude. Humidity also increases the corona current, which indication is included in the total leakage current. Wind prevents the accumulation of space charges at all bare energized terminals. This results in an increase of corona. It is most desirable to reduce or eliminate corona current at the bare metal extremities of cable or terminations. This may be accomplished by covering these areas with plastic envelopes, plastic or glass containers, plastic wrap (e.g. “Saran” or “Handiwrap®”) or suitable electrical putty.

Routine periodic dc maintenance testing of cable for the evaluation of the insulation strength is not a common practice. Some power cable users have adopted a program of testing circuits during planned outages, preferring possible breakdowns during testing rather than experiencing a service outage. It is nearly impossible to recommend test voltage values for those maintenance tests with the history of the cable circuit. An arbitrary test voltage level could break down a cable circuit that would otherwise render long trouble-free service at normal operating ac voltage.

The main usefulness of dc high-voltage testing is to detect conducting particles left on the creepage surface during splicing or termination.

Test equipment should be supplied from a stable, constant voltage source. Do not use the same source that is supplying arc welders or other equipment causing line voltage fluctuations. The output voltage of the test set must be filtered and regulated. Consider using a portable motor driven alternator to energize test set.

The gradual decrease or non-increase of leakage current with respect to time at maximum test voltage is the acceptance criteria for dc hi-pot testing.

Testing Problems

Extra Leakage Current:

- Failure to guard against corona
- Failure to clean insulation surface
- Failure to keep cable ends dry
- Failure to provide adequate clearance to ground
- Improper shield termination

Erratic Readings:

- Fluctuating voltage to test set
- Improper test leads

Environmental influences:

- High relative humidity
- Dampness, dew, fog
- Wind, snow

Results vs. Cable Life

To date there is no bases for correlation between dc test results and cable life expectancy.

Partial Listing of Equipment Suppliers

J.G. Biddle Company
Blue Bell, PA 19422

Hipotronics
Brewster, NY 10519

Associated Research Inc.
Chicago, IL 60648

Von Corporation
Birmingham, AL 35211

Cable Testing

Maximum DC Test Voltages for Shielded Cables

National Electrical Manufacturers' Association & IEEE Standard 400

EPR	=	NEMA WC-8, ICEA S-68-516	NEMA WC 74	ICEA S-93-639	Shielded Power Cable
XLP	=	NEMA WC-7, ICEA S-66-524		AEIC CS8	Shielded Power Cable
PE	=	NEMA WC-5, ICEA S-61-402			

RATED CIRCUIT VOLTAGE PHASE TO PHASE VOLTS	CONDUCTOR SIZE AWG-kcmil
2001-5000	8-1000
5001-8000	6-1000
8001-15000	2-1000 (1)
	1-1000 (1)
15001-25000	1-1000
25001-28000	1-1000
28001-35000	1/0-1000

(1) Combined in S-61-402, S-68-516

ACCEPTANCE	
100% (FOR GROUNDED)	133% (FOR UNGROUNDED)
kV	kV
25	25
35	35
55	–
–	65 (2)
80	100 (2)
85	–
100	-

(2) Not in IEEE-400

General Cable does not make any recommendations for maintenance testing.

Test to be made immediately after installation.

Dimensions and weights are nominal; subject to industry tolerance.

Cable Testing

Field Electrical "Hi-Pot" Testing
AEIC CS8 (Formerly AEIC CS5, AEIC CS6)

Acceptance Test

This test is performed to detect any defects in cable insulation and terminations which may result from poor workmanship or mechanical damage. DC testing is not expected to reveal deterioration due to aging in service.

This proof test confirms the integrity of the insulation and accessories before the cable is put into service. Tests are recommended during installation at the DC test voltage specified in the Table below, applied for 5 consecutive minutes (General Cable will allow a 15 minute test), at the following stages:

1. Immediately after the cable is in place
2. After the cable splicing and/or terminating, before energization

Maintenance Test After Installation

After the cable has been completely installed and placed in service, a DC proof test may be made at any time within the first five years at a voltage not exceeding the DC test voltage specified in the table below under the First 5 Years column, applied for 5 consecutive minutes. After that time, DC testing is not recommended.

DC test values

Maximum DC Field Test Voltages

RATED VOLTAGE PHASE-TO-PHASE KV	CONDUCTOR SIZE AWG OR kcmil (mm2)	INSULATION THICKNESS MILS (mm)		DC TEST VOLTAGES - kV DURING INSTALLATION		DC TEST VOLTAGES - kV FIRST 5 YEARS	
		A	B	A	B	A	B
< 5*							
5	8-1000 (8.4-507)	90 (2.29)	115 (2.92)	28	36	9	11
	Above 1000 (507)	140 (3.56)	140 (3.56)	28	36	9	11
8	6-1000 (13.3-507)	115 (2.92)	140 (3.56)	36	44	11	14
	Above 1000 (507)	175 (4.45)	175 (4.45)	36	44	11	14
15	2-1000 (33.6-507)	175 (4.45)	220 (5.59)	56	64	18	20
	Above 1000 (507)	220 (5.59)	220 (5.59)	56	64	18	20
25	1-2000 (42.4-1013)	260 (6.60)	320 (8.13)	80	96	25	30
28	1-2000 (42.4-1013)	280 (7.11)	345 (8.76)	84	100	26	31
35	1/0-2000 (53.5-1013)	345 (8.76)	420 (10.7)	100	124	31	39
46	4/0-2000 (107.2-1013)	445 (11.3)	580 (14.7)	132	172	41	54

Column A – 100% Insulation
Column B – 133% Insulation

* "Hi-Pot" testing generally not performed. The insulation resistance of the system is meggered.

DCtest voltages are applied to discover gross problems such as improperly installed accessories or mechanical damage. DC testing is not expected to reveal deterioration due to aging in service. There is some evidence that DC testing of aged cross-linked polyethylene cables can lead to early cable failures. Information on this subject is available in EPRI project report TR-101245, "Effect of DC Testing in Extruded Cross-Linked Polyethylene Insulated Cables."

Dimensions and weights are nominal; subject to industry tolerance.