22 TECHNICAL

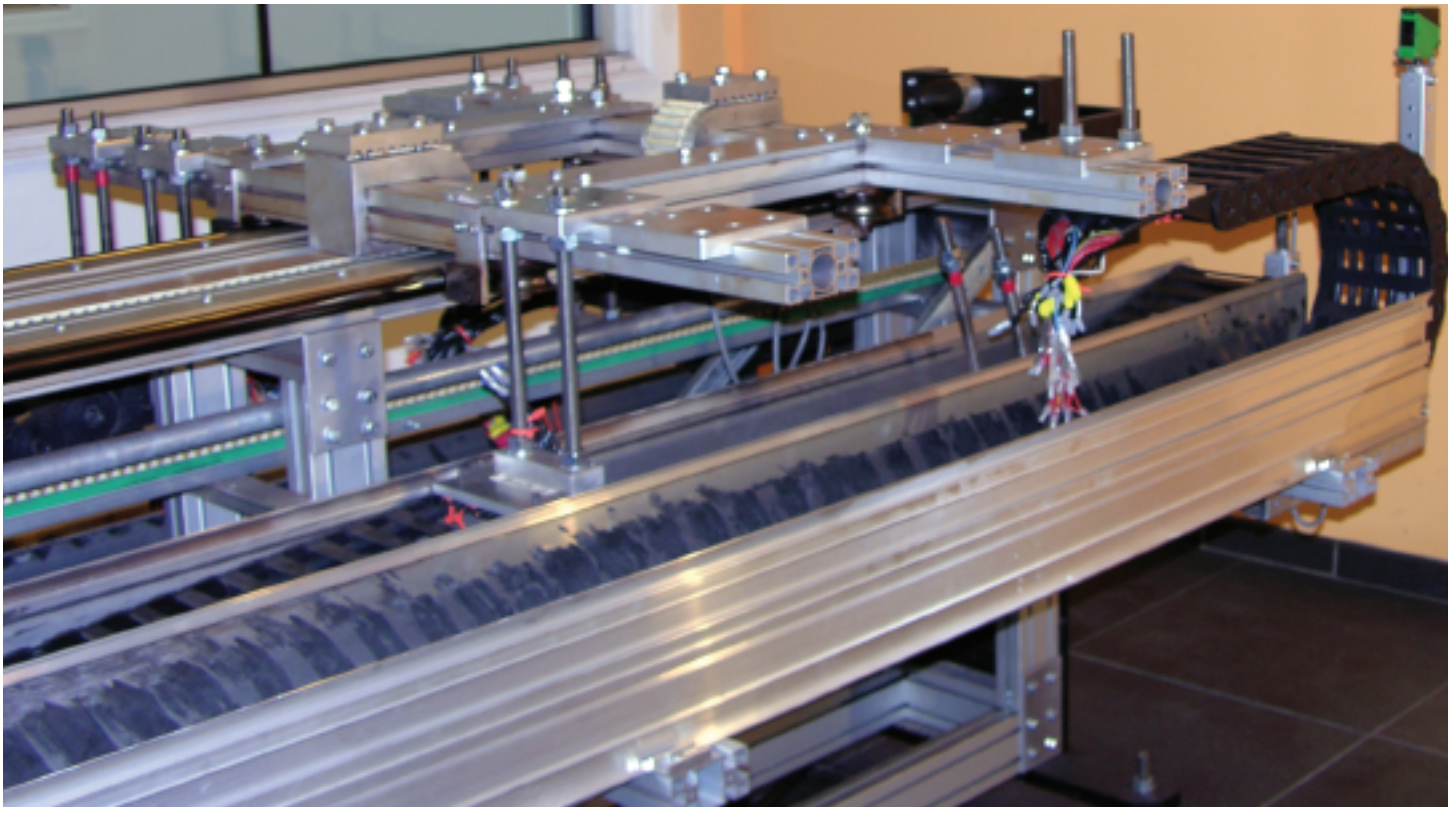
Technical Data

Technical Data

Lapp North America Laboratory

For half a century, the Lapp Group's products have been expertly designed, processed and manufactured with state of the art equipment, guaranteeing the finest flexible cable products available. Our credibility and expertise have classified Lapp as the "innovator" in the industrial flexible cable market.

At Lapp Group, our cable designs are evaluated under the most extreme test conditions. The addition of the Lapp Group North American Test Center provides the capability to perform air oven aging, oil resistance, cold temperature, and other mechanical, electrical and environmental cable testing. In addition, this will be a fully UL/CSA/ISO certified lab which will improve Lapp's speed in the UL and CSA approval process for all new researched compounds and finished goods.



Testing Capabilities:

- Cold Testing
- Flex Testing
- Torsion Testing
- Oil Testing
- Electrical Testing
- Crush & Impact
- Insulation Resistant
- VW-1 Flame Testing
- Mechanical Testing

Certified Lab: August 2008*

*** Pending**

Cable Attributes

Cable Attributes

OIL RESISTANCE

FLAME RESISTANCE LEVELS

MOTION TYPE

MECHANICAL PROPERTIES

Over 50 years ago company founder, Oskar Lapp, designed and manufactured the world's first multi-conductor control cable. Ever since the Lapp Group has been known as the worldwide leader in flexible cable technology.

Through continual R&D and the extensive knowledge of our engineers; the Lapp Group has developed criteria which will aid the cable user in deciding which cable is best suited to their application.

As you will find on the following pages, the Lapp Group has brought cable specifying to a new level for the following product attributes: Oil Resistance, Flame Resistance Levels, Motion Types, and Mechanical Properties. By setting the criteria for such important attributes, our engineers have given the cable buyer a more precise and definitive way to choose the cable that's right for their specific application or environment.

The symbols located at the top of the page relate to applicable Lapp products and can be found on the product pages within this catalog. To help you choose the Lapp cable that best suits your requirements, we suggest you review the criteria and definitions on the following pages and familiarize yourself with the different levels.

The Lapp Group will strive to continue to provide creative solutions and the highest quality products you've come to expect.

*Disclaimer: These criteria are to be used as guidelines, and not definitive test results.
Please contact your Lapp sales representative for specific testing results.

Fire Protection Logo

The Lapp Group has added the fire protection logo on the product pages for cables that comply to the new NFPA 79 2007 Standard and NEC 2008. For more information, regarding the new NFPA 79 standards, see page 660 or visit www.lappusa.com to download our white paper.

* NEC® is a registered trademark of the National Fire Protection Association.

Cable Attributes

Oil Resistance

Level	USA	CSA*	Europe*
OR-00	No oil resistance characteristics	------	------
OR-01	UL 62 One week test, In oil for 7 days @60°C 75% Unaged Tensile Strength 75% Unaged Elongation	C22.2 No.49 In oil for 7 days @60°C 75% Unaged Tensile Strength 75% Unaged Elongation	VDE 0281 Part 1 In oil for 7 days @60°C ± 30% Unaged Tensile Strength ± 30% Unaged Elongation
OR-02	UL Oil Res. I. In oil for 4 days @100°C 50% Unaged Tensile Strength 50% Unaged Elongation	C22.2 No.230 In oil for 4 days @100°C 50% Unaged Tensile Strength 50% Unaged Elongation	VDE 0472 Sect 803A In oil for 1day @100°C ± 25% Unaged Tensile Strength ± 25% Unaged Elongation
OR-03	UL Oil Res. II. In oil for 60 days @75°C 65% Unaged Tensile Strength 65% Unaged Elongation	C22.2 No.210.2 In oil for 4 days @100°C 65% Unaged Tensile Strength 65% Unaged Elongation	SEV TP 20 B In oil for 30 Days @70°C No cracking after bending
OR-04	UL AWM 21098 In oil for 60 days @80°C 65% Unaged Tensile Strength 65% Unaged Elongation	C22.2 No 0.3 For 60 days @80°C 65% Unaged Tensile Strength 65% Unaged Elongation	VDE 0472 Sect 803B In oil for 7days @ 90°C ± 25% Unaged Tensile Strength ± 25% Unaged Elongation
OR-05	In oil for 3 Weeks @100°C 100% Unaged Tensile Strength 110% Unaged Elongation		
OR-06	In oil for 7 days @180°C 80% Unaged Tensile Strength 60% Unaged Elongation		

*Note: These oil immersion standards are mentioned for purposes of reference only. Some Canadian and European test standards are not necessarily represented here as complete equivalents to the US Standards but have been referenced due to similarities in requirements. Refer to the individual standards for detailed test procedures and any comparable evaluations.

The type of industrial environment and other factors such as the duration of oil exposure and quantity of the liquid all attribute to the specific level of oil protection needed. Other parameters such as the surrounding ambient, temperature of the oil and the cable itself will also play a role in determining the cables ability to withstand this type of chemical exposure. In general, the greater the ability of the cable jacket to resist the possible devastating effects of oil, the longer it will perform uninterrupted in the application. Certain industries (Grinding, Machine tools, painting etc.) will require the highest degree of oil resistance available, while other applications (office buildings, residential dwellings, etc.) will only need a minimal amount of this type of protection. The Lapp Group provides a large product offering of cables in a wide array of different constructions that will the meet varying degrees of oil resistance required for your application.

Cable Attributes

Flame Resistance

Level	USA	CSA*	Europe*
FR-00	Little or no flame retardancy, cable ignites and burns easily, and will not extinguish itself	---	---
FR-01	UL 62, Horizontal Flame test one 30 second flame application, must not emit flame or glowing particles	FT2, one 30 second flame application, must not emit flame or glowing particles	VDE 0472 Part 804 one 1-minute flame application, must not ignite or emit flames
FR-02	UL VW-1, Vertical Flame test, five 15 second flame applications, must not emit flame or glowing particles	FT1, Vertical flame test, five 15 second flame applications, must not emit flame or glowing particles	IEC 60332-1, flame application time varies by cable diameter, must self-extinguish
FR-03	UL Vertical Tray test exposed to flame for twenty minutes, damage cannot exceed 8 feet	FT4, Vertical Tray test exposed to flame for twenty minutes, damage cannot exceed 5 feet	IEC 60332-3-24, exposed to flame for twenty minutes, damage cannot exceed 8.2 feet
FR-03.1	UL Vertical Tray Fire Propagation exposed to flame for twenty minutes, damage cannot exceed 8 feet, smoke release not to exceed $95m^2$	FT4-ST1,Vertical Tray Fire Propagation exposed to flame for twenty minutes, damage cannot exceed 8 feet, smoke release not to exceed $95m^2$	IEC 60332-3-25, exposed to flame for 20 minutes, damage cannot exceed 8.2 feet.
FR-04	UL Flame test for Riser cables Flame spread cannot exceed 12 ft.; Measured temperature at any point cannot be greater than 850°F	----	----
FR-05	UL Flame test for Plenum cables exposed to flame for twenty minutes, damage cannot exceed 5 feet, peak smoke optical density not to exceed .50	FT6, exposed to flame for twenty minutes, damage cannot exceed 5 feet peak smoke optical density not to exceed .50	IEC 61034-2 exposed to flame for a maximum of 40 minutes, minimum value of 60% light transmittance.

*Note: These flame standards are mentioned for purposes of reference only. Some Canadian and European test standards are not necessarily represented here as complete equivalents to the US Standards but have been referenced due to some similarities in requirements. Refer to the individual standards for detailed test procedures and any comparable evaluations.

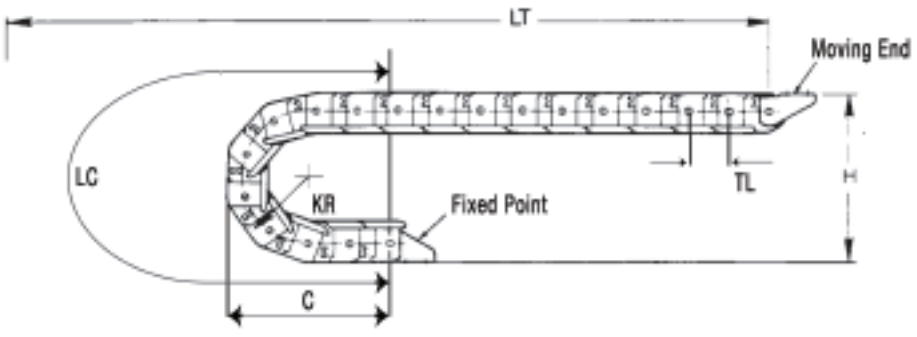
Lapp cables are manufactured to comply with varying degrees of flame resistance requirements. Depending upon your application, certain levels of flame resistance are necessary in order to meet specific end use requirements. Flammability ratings generally determine the end use application, which is generally dictated by local or national electrical codes. Certain applications require a minimal amount of flame resistance such as UL 62 or CSA FT2 for flexible cordage. In this instance, the end use of these products do not deem the necessity of imposing a high flammability requirement. Other applications such as cables that will be installed permanently within an industrial building, commercial dwelling or family residence will most likely require a higher degree of flammability resistance such as a UL Vertical Tray or CSA FT4. Whatever the end use application, the Lapp Group offers a wide variety of cable products meeting different levels of flame resistance to meet your requirements.

Cable Attributes

Motion

Level	Description	Definition	Cycle Life Range*
FL-00	Very Stiff (Static)	Low strand count and difficult to work with, used in static applications	---
FL-01	Flexible	Can be easily installed in machines, conduit and cable tray when applicable	---
FL-02	Highly Flexible	High flexibility with continuous flexing design attributes	---
CF-01	Continuous Moderate Flexing	Designed for Continuous Flexing and Cable Track Applications Applications - Chain Length up to 30 feet	2 - 8 million
CF-02	Continuous High Flexing	Designed for High Cycle Continuous Flexing and Cable Track Applications - Chain Length up to 30 feet	8 - 20 million
CF-03	Continuous High Flexing	Designed for High Cycle Continuous Flexing and Long Cable Track Applications - Chain Length up to 300 feet	8 - 20 million
T-01	Torsion	Designed to withstand Torsion Applications	2 million
TCF-01	Torsion & Continuous Flex	Designed for High Cycle Continuous Flexing and Torsion Applications	10 million

* When comparing cycle life data between cables, the following critical variables must be evaluated.



BR= Bend radius (in.)
LT= Distance of Travel Length (ft.)
A= Acceleration (ft./Sec_)
S= Speed (ft./Sec.)

It is important to note that the test variables must be identical otherwise the comparison is invalid.

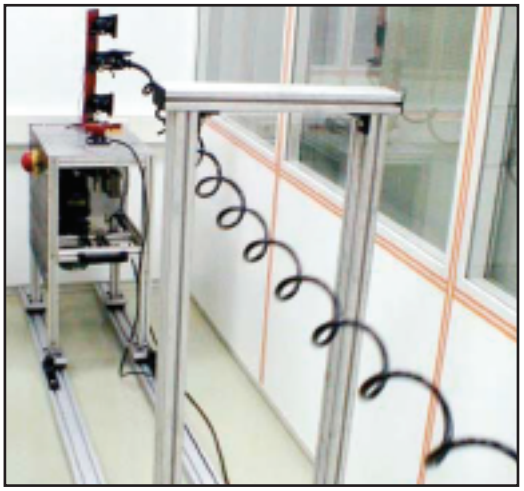
The Lapp Group's cable designs are evaluated under the most extreme test conditions. The cycle life testing ranges mentioned above do not indicate cable flex cycle failure, but is only an indicator of suggested range for the intended application. When Lapp continuous flex cables are installed correctly in the application, a longer service life will result. For almost half a century, Lapp products have been expertly designed, processed and manufactured with state of the art equipment, guaranteeing the finest flexible cable products available. Our credibility and expertise have classified Lapp as the "innovator" in the Industrial flexible cable and robotic industry.

Cable Attributes

Flex Life Testing Parameters

Test Conditions for Continuous Flex Cables:

Minimum Bend Radius Range Factor:	5.0 – 15.0 x Cable diameter
Bending Radius Range Factor During Testing:	4.0 – 12.0 x Cable diameter
Travel Distance Under Test Conditions:	18 Feet
Acceleration Under Test Conditions:	Varies up to 26 Feet per second
Temperature Range During Test:	+10°C to +22°C
Speed of Travel During Test:	Varies from 6.5 to 13 Feet per second



Test Conditions for Torsion Cables:

Standard Torsion Stress:	+/- 450°/ 1 meters
Severe Torsion Stress:	+/- 450°/ .5 meters
Bending Radius Range Factor During Test:	10.0 – 12 x Cable diameter

Cable Attributes

Mechanical Resistance

Level	Description	Impact	Crush	Cold Impact	Tensile	Elongation	Standard
MP-00	No extra-mechanical resistance properties	-	-	-	-	-	-
MP-01	Average	*	*	-	1500 Psi	100%	ASTM D-412
MP-02	Good – Independent lab tested for crush & Impact	10/50 Lbs.	1000/2000 Lbf.	-	1700 Psi	175%	UL 1277 ASTM D-412
MP-03	Very Good – Rated for Exposed Run use (–ER)	10/50 Lbs.	2000/4000 Lbf.	-25°C (CSA-TC)	2300 Psi	275%	UL 1277 ASTM D-412
MP-04	Excellent	**	**	-	3400 Psi	325%	ASTM D-1457
MP-05	Superior	**	**	-	4200 Psi	500%	ASTM D-412

* Impact and Crush tests not applicable for intended end use of product.

** Testing not required, however, if tested, these groups would meet or exceed UL 1277 Impact and Crush requirements by virtue of their superior mechanical properties.

Depending upon the specific application, a cable may be exposed to external factors and various types of abuse. The explicit type of industrial manufacturing or processing environment will determine the actual degree of mechanical protection that a cable requires. CNC machine centers, Mining, Food and Beverage plants, Automotive Assembly facilities, Machine tools, Data Processing, Automation, etc. applications all require a certain level of mechanical protection. The unintentional mishaps that occur everyday during routine manufacturing can range anywhere from a cable being struck by a falling object, to it being accidentally run over. There are many other types of mechanical abuse that are common in an industrial environment. With all the possibilities that your cable may be exposed to, you will need the protection and reliability that is provided in the many design configurations that are offered by the Lapp Group.

RoHS Designation
Halogen vs. Non-Halogen

RoHS & WEEE Directives

As of July 1st 2006, certain substances are banned from inclusion in new electrical and electronic equipment.

These substances are:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- Polybrominated biphenyl (PBB)
- Polybrominated diphenylether (PBDE)

In certain substances, limited values or exceptions apply, which are specified in EU Guidelines 2002/95/EC.

The importance of eliminating lead from cables began in the European and Asian markets.

International Regulations & Directives are in the process of eliminating lead.

RoHS (2002/95/EC)

(Restriction of Hazardous Substances)

Requires that manufacturers, distributors and sellers comply with eliminating certain hazardous substances from New Electrical and Electrical equipment by July 1, 2006.

All new production of standard Lapp cables are manufactured with compounds that meet the RoHS directive. These cables will be identified by the designation “pbf(+)” on the jacket print legend.

WEEE (2002/96/EC)

Waste Electronic and Electrical Equipment - requires that manufacturers, distributors and sellers of specific appliances, and electrical equipment provide recycling and disposal facilities for their products as of August 13, 2005.

The use of non-lead compounds will not compromise the integrity of any Lapp product's ability to provide continued optimum performance.

Halogen vs. Non-Halogen

Halogens are present in many and wire cable compounds or they are added in as part of the flame retardant component during formulation. The interest for Non-Halogen wire and cable products in the European marketplace remains high while this is not the case in the United States. The advantage of cables that do not contain halogen is that during a fire neither high levels of smoke or corrosive gases are emitted. Non-halogen wire and cable compound formulations include antimony-based systems to replace traditional flame-retardants, which contain chlorides, fluorides and bromides.

NFPA 79 Cable Requirements

Save Time and Money by Meeting the Requirements

NFPA 79 is the section of the National Electric Code (NEC®) that focuses on the electrical wiring standards used with industrial machinery. NFPA 79 applies to the electrical equipment used within a wide variety of machines, as well as groups of machines working together in a coordinated manner. Examples of industrial machinery include, among others: machine tools, injection molding machines, woodworking equipment, assembling machinery, material handling machinery and inspection and testing machines. The scope of NFPA 79 includes all electrical and electronic elements of the machinery operating at 600V or less.

In 2007, the NFPA 79 code underwent significant revisions. The main goal of the revision was to harmonize NFPA 79 with its European counterpart, IEC-60204. This involved reorganizing the NFPA 79 chapter structure to follow IEC-60204 while adopting less restrictive, more progressive requirements without sacrificing the equipment safety.

As of January 2007, one of the major changes in the NFPA 79 is the cable selections required under section 12.2.7.3. This section states that single conductor or multi-conductor AWM shall not be permitted, unless the completed assembly has been listed prior for such use. Machine Tool Wire (MTW) is one of the wire and cable permissible options.

Historically, little attention has been given to cable selection; often it was an after thought. Today, however, with ever increasing concerns of liability issues, more time is devoted to machine components such as wire and cable to ensure performance reliability. Regardless of the product, the strength of quality is only as good as its weakest component.

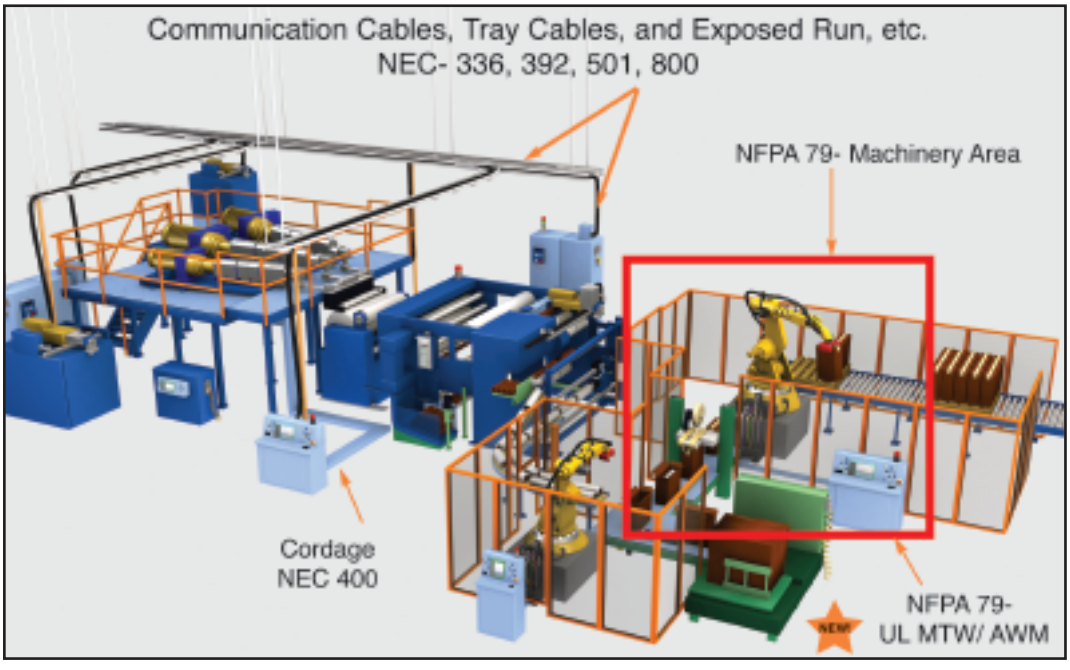
With present day global supply access, it is more important than ever to meet regulatory requirements and proper cable selection for industrial machinery.

In keeping with the Principles of the Lapp Group, customer education is at the top of the list. We strive to keep our customers aware of breaking industry changes. For a more detailed technical explanation, please visit Lapp USA's website at www.lappusa.com. Go to APPLICATIONS, then to “NFPA 79 Compliant”. Once there you will see our white paper and a PDF of all the Lapp products that comply to the NFPA 79 2007 Edition. These products also have the new logo (see left) denoting they compliance with this standard.

The cost of improper cable selection and non-compliance is too expensive in today's highly competitive market place. Save time and money now. Lapp USA can assist in the selection of the proper cable for your installation. Please contact one of our Technical Representatives today.

Lapp USA offers a variety of product solutions that are UL Listed and conform to the NFPA 79 2007 Edition.

The diagram illustrates key NEC and NFPA regulatory codes for an industrial plant manufacturing floor. Each code calls out permissible cables.



* NEC® is a registered trademark of the National Fire Protection Association.

European Cable Stranding

Guidelines have been established for measuring conductor sizes within the European Cable industry. In the past, conductors were normally measured by either their cross sectional area, number and diameter of individual strands, or both. The new system for flexible conductors (column 3 & 4 below) centers around the maximum strand diameter and the conductor resistance. In view of this, some cables may have less strands and a smaller diameter than listed below but still conform to BS 6360, VDE 0295, and IEC 228 by meeting conductor resistance requirements.

Cross Section mm^2	Strands VDE 0295 BS 6360 Class 2 (1)	Multi-wire Strands (2)	Fine-Wire Strands VDE 0295 BS 6360 Class 5 (3)	Fine-Wire Strands VDE 0295 BS 6360 Class 6 (4)	Super Fine Wire Strands (5)	Super Fine Wire Strands (6)	Super Fine Wire Strands (7)
0.05							24 x 0.05
0.08							41 x 0.05
0.14				18 x 0.10	18 x 0.1	36 x 0.07	72 x 0.05
0.25			14 x 0.16	32 x 0.10	32 x 0.1	65 x 0.07	128 x 0.05
0.34		7 x 0.25	19 x 0.16	42 x 0.10	42 x 0.1	88 x 0.07	174 x 0.05
0.38		7 x 0.27	12 x 0.21	21 x 0.15	48 x 0.1	100 x 0.07	194 x 0.05
0.50	7 x 0.30	7 x 0.30	16 x 0.21	28 x 0.15	64 x 0.1	131 x 0.07	256 x 0.05
0.75	7 x 0.37	7 x 0.37	24 x 0.21	42 x 0.15	96 x 0.1	195 x 0.07	384 x 0.05
1.0	7 x 0.43	7 x 0.43	32 x 0.21	56 x 0.15	128 x 0.1	260 x 0.07	512 x 0.05
1.5	7 x 0.52	7 x 0.52	30 x 0.26	84 x 0.15	192 x 0.1	392 x 0.07	768 x 0.05
2.5	7 x 0.67	19 x 0.41	50 x 0.26	140 x 0.15	320 x 0.1	651 x 0.07	1280 x 0.05
4	7 x 0.85	19 x 0.52	56 x 0.31	224 x 0.15	512 x 0.1	1040 x 0.07	
6	7 x 1.05	19 x 0.64	84 x 0.31	192 x 0.20	768 x 0.1	1560 x 0.07	
10	7 x 1.35	49 x 0.51	80 x 0.41	320 x 0.20	1280 x 0.1	2600 x 0.07	
16	7 x 1.70	49 x 0.65	128 x 0.41	512 x 0.20	2048 x 0.1		
25	7 x 2.13	84 x 0.62	200 x 0.41	800 x 0.20	3200 x 0.1		
35	7 x 2.52	133 x 0.58	280 x 0.41	1120 x 0.20			
50	19 x 1.83	133 x 0.69	400 x 0.41	705 x 0.30			
70	19 x 2.17	189 x 0.69	356 x 0.51	990 x 0.30			
95	19 x 2.52	259 x 0.69	485 x 0.51	1340 x 0.30			
120	37 x 2.03	336 x 0.67	614 x 0.51	1690 x 0.30			
150	37 x 2.27	392 x 0.69	765 x 0.51	2123 x 0.30			
185	37 x 2.52	494 x 0.69	944 x 0.51	1470 x 0.40			
240	61 x 2.24	627 x 0.70	1225 x 0.51	1905 x 0.40			
300	61 x 2.50	790 x 0.70	1530 x 0.51	2385 x 0.40			
400	61 x 2.89		2035 x 0.51				
500	61 x 3.23		1768 x 0.51				

NOTE: The number of wires in columns (3) - (7) is optional. VDE 0295 specifies only the maximum diameter of the individual wires and the maximum resistance assigned to the cross-section.

AWG	Strand	mm^2	CLASS 5	mm^2	DCR	CLASS 6	Strand	mm^2
26				.14	42.0	18 /. 10	7/34	0.14
24			14 / .15	.25	24.0	32 / .10	10/34	0.20
22	7/30	0.35	19 / .15	.34	17.3	42 / .10	19/34	0.38
20	10/30	0.51	16 / .21	.50	11.88	28 / .15	26/34	0.52
18	19/30	1.00	24 / .21	.75	7.92	42 / .15	41/34	0.83
			32 / .21	1.0	5.94	56 / .15		
16	26/30	1.32	30 / .26	1.5	4.05	84 / .15	65/34	1.31
14	41/30	2.08	50 / .26	2.5	2.43	140 / .15	105/34	2.11
12	65/30	3.30	56 / .31	4	1.50	224 /.15	168/34	3.38
10	105/30	5.32	84 / .31	6	1.00	192 / .20	259/34	5.21
8	168/30	8.52	80 / .41	10	.582	320 / .20	413/34	8.31
6	266/30	13.5	128 / .41	16	.368	512 / .20	665/34	13.40
4	413/30	21.0	200 / .41	25	.237	800 / .20	1064/34	21.40
2	665/30	33.7	280 / .41	35	.168	1120 / .20	1666/34	33.50
1	836/30	43.0	400 / .41	50	.117	705 / .30	2109/34	42.0
2/0	1330/30	67.0	356 / .50	70	.082	990 / .30		
3/0			485 / .50	95	.062	1340 / .30		
4/0	2107/30	106	614 / .50	120	.049	1690 / .30		
300 KCMIL			765 / .50	150	.039	2123 / .30		
350 KCMIL			944 / .50	185	.032	1470 / .40		
500 KCMIL			1225 / .50	240	.024	1905 / .40		
600 KCMIL			1530 / .50	300	.019	2385 / .40		
750 KCMIL			2035 / .50	400	.014			
1000 KCMIL			1768 / .60	500	.011			

Stranded Conductors- AWG

AWG	Stranding	Diameter		Cross-Sectional Area		Weight	DCR @ 20°C-OHMS/ mft	
		Inches	mm²	CMA*	mm²	lbs./ mft	Bare Cu.	Tinned Cu.
30	7/38	0.012	0.3048	112.00	0.0567	0.339	100.3	107.7
30	19/42	0.013	0.3302	118.75	0.0589	0.359	101.9	109.4
28	7/36	0.015	0.3810	175.00	0.0889	0.550	63.55	68.22
28	19/40	0.016	0.4064	182.59	0.0931	0.590	63.06	67.69
27	7/35	0.017	0.4318	219.52	0.1113	0.632	50.44	54.15
27	65/44	0.018	0.4572	260.00	0.1235	0.700	49.41	53.05
26	7/34	0.019	0.4826	277.83	0.1407	0.870	39.70	42.61
26	10/36	0.020	0.5080	250.00	0.1270	0.770	44.92	48.21
26	19/38	0.020	0.5080	304.00	0.1539	0.930	37.33	40.07
24	7/32	0.024	0.6096	448.00	0.2268	1.380	24.46	26.25
24	10/34	0.023	0.5842	396.90	0.2010	1.220	28.06	31.12
24	19/36	0.025	0.6350	475.00	0.2413	1.470	23.64	25.38
24	41/40	0.024	0.6096	384.40	0.2009	1.250	29.78	31.97
22	7/30	0.030	0.7620	700.00	0.3542	2.190	15.57	16.72
22	19/34	0.032	0.8128	754.11	0.3819	2.320	14.77	16.1
22	26/36	0.029	0.7366	650.00	0.3302	1.970	17.44	18.72
20	7/28	0.038	0.9652	1111.00	0.5628	3.490	9.81	10.42
20	10/30	0.036	0.9144	1000.00	0.5060	3.140	11.00	11.81
20	19/32	0.038	0.9652	1216.00	0.6156	3.750	9.10	9.765
20	26/34	0.040	1.0160	1031.94	0.5226	3.210	10.90	11.70
20	41/36	0 038	0.9652	1025.00	0.5207	3.170	11.17	11.99
18	7/26	0 046	1,1684	1769.60	0.8960	5.040	6.165	6.550
18	16/30	0.046	1.1684	1600.00	0.8096	5.000	6.877	7.384
18	19/30	0.048	1.2192	1900.00	0.9614	5.900	5.791	6.218
18	41/34	0.046	1.1684	1627.29	0.8241	5.060	6.975	7.487
18	65/36	0.048	1.2192	1625.00	0.8255	5.000	7.043	7.560
16	7/24	0.060	1.5240	2828.00	1.4322	8.560	3.855	4.002
16	19/29	0.054	1.3716	2426.30	1.2293	7.500	4.538	4.817
16	26/30	0.058	1.4732	2600.00	1.3156	8.060	4.273	4.588
16	65/34	0.059	1.4986	2579.85	1.3065	8.030	4.400	4.723
16	105/36	0.059	1.4986	2625.00	1.3335	8.090	4.360	4.680
14	7/22	0.073	1.8542	4480.04	2.2694	12.76	2.428	2.531
14	19/27	0.068	1.7272	3830.40	1.9399	12.50	2.874	3.054
14	41/30	0.070	1.7780	4100.00	2.0746	12.88	2.735	2.937
14	105/34	0.086	2.1844	4167.50	2.1105	13.00	2.724	2.924
12	7/20	0.096	2.4384	7168.0	3.6302	21.69	1.516	1.574
12	19/25	0.090	2.2860	6087.6	3.0837	19.70	1.806	1.916
12	65/30	0.102	2.5908	6500.00	3.2890	20.76	1.725	1.853
12	165/34	0.095	2.4130	6548.90	3.3165	19.82	1.750	1.878
10	37/26	0.110	2.7940	9353.60	4.7360	29.00	1.189	1.263
10	49/27	0.116	2.9464	9878.40	5.0029	29.89	1.136	1.207
10	105/30	0.120	3.0480	10530.00	5.3130	33.10	1.068	1.147
8	49/25	0.147	3.7338	15699.60	7.9527	47.53	0.714	0.757
8	133/29	0.166	4.2164	16984.11	8.6051	52.87	0.661	0.701
8	655/36	0.147	3.7338	16625.01	8.3185	51.30	0.706	0.757
6	133/27	0.206	5.2324	26812.80	13.5793	81.14	0.418	0.445
6	266/30	0.210	5.3340	25900.01	13.4596	86.01	0.426	0.457
6	1050/36	0.184	4.6736	26250.01	13.3350	79.47	0.440	0.472
4	7x19/25	0.257	6.5278	42613.00	21.5859	133.00	0.263	0.279
4	259/27	0.232	5.8928	52214.40	26.4439	158.02	0.217	0.231
4	1666/36	0.232	5.8928	41650.00	21.1582	126.10	0.277	0.298
2	133/32	0.292	7.4168	67936.40	34.4071	205.62	0.164	0.171
2	259/26	0.292	7.4168	65475.20	33.1520	198.14	0.173	0.184
2	665/30	0.328	8.3112	66500.00	33.1430	213.00	0.170	0.183
2	2646/36	0.292	7.4168	66150.00	33.6042	200.28	0.175	0.187
1	19/.0664	0.328	8.3312	82983.60	42.4700	251.20	0.134	0.137
1	19x44/30	0.377	9.5758	81700.00	43.3016	267.79	0.135	0.171
1	2109/34	0.328	8.3312	83706.20	42.3909	253.29	0.137	0.147
1/0	133/21	0.368	9.3472	108035.90	54.7162	327.05	0.104	0.108
1/0	259/24	0.368	9.3472	104636.00	52.9914	316.76	0.108	0.112
2/0	133/20	0.414	10.5156	136192.00	68.9738	412.17	0.0821	0.0853
2/0	259/23	0.414	10.5156	132297.20	67.0033	400.41	0.0855	0.0888
2/0	1330/30	0.406	10.3124	133300.00	67.2980	430.00	0.0851	0.0914
3/0	259/22	0.464	11.7856	163195.00	83.9678	501.70	0.0682	0.0711
3/0	427/24	0.464	11.7856	172508.00	87.3642	522.20	0.0657	0.0682
4/0	259/21	0.597	15.1638	210385.70	106.5526	638.88	0.0537	0.0558
4/0	427/23	0.598	15.1892	218111.60	110.4649	660.01	0.0519	0.0539
4/0	2107/30	0.608	15.4432	211468.00	106.6142	653.00	0.0537	0.0577

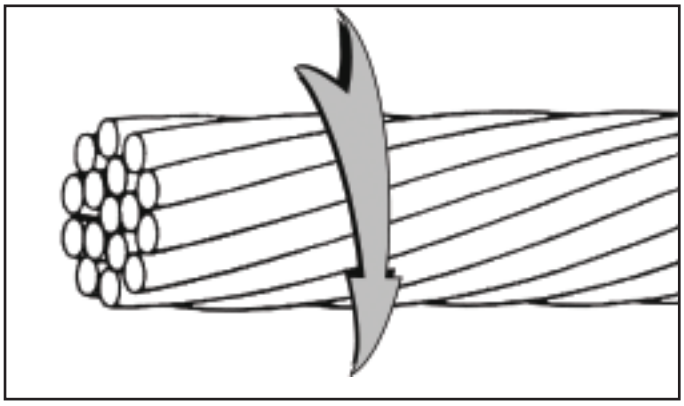
Solid Conductors- AWG

AWG	Diameter		Cross-Sectional Area		DCR @ 20ºC-OHMS/mft		Weight	Break Strength
	Inches	mm²	CMA*	mm²	Bare Cu.	Tinned Cu	lbs./ mft	Lbs./ Max
40	.0031	0.078740	9.61	0.0049	1552	1236.6	0.0291	0.3106
39	.0035	0.088900	12.3	0.0062	897.1	963.0	0.0371	0.3917
38	.0040	0.101600	16.0	0.0081	681.9	732.0	0.0484	0.4939
37	.0045	0.114300	20.3	0.0103	535.7	575.1	0.0613	0.6228
36	.0050	0.127000	25.0	0.0127	431.9	463.6	0.0757	0.7854
35	.0056	0.142240	31.4	0.0159	342.8	368.0	0.0949	0.9904
34	.0063	0.160020	39.7	0.0201	269.8	289.6	0.120	1.249
33	.0071	0.180340	50.4	0.0255	211.7	227.3	0.153	1.575
32	.0080	0.203200	64.0	0.0324	166.2	178.4	0.194	1.986
31	.0089	0.226060	79.2	0.0401	133.9	143.7	0.240	2.504
30	.0100	0.254000	100	0.0506	105.8	113.6	0.3042	3.157
29	.0113	0.287020	128	0.0647	82.9	88.0	0.387	3.981
28	.0126	0.320040	159	0.0804	66.7	70.8	0.481	5.020
27	.0142	0.360680	202	0.1021	52.5	55.8	0.610	6.331
26	.0159	0.403860	253	0.1280	41.9	44.5	0.765	7.983
25	.0179	0.454660	320	0.1623	33.0	35.0	0.970	10.07
24	.0201	0.510540	404	0.2046	26.2	27.2	1.22	12.69
23	.0226	0.574040	511	0.2587	20.7	21.5	1.55	15.41
22	.0253	0.642620	640	0.3242	16.5	17.2	1.94	19.43
21	.0285	0.723900	812	0.4114	13.0	13.5	2.46	24.50
20	.0320	0.812800	1020	0.5186	10.3	10.7	3.10	30.89
19	.0359	0.911860	1290	0.6527	8.21	8.54	3.90	38.95
18	.0403	1.023620	1620	0.8225	6.52	6.78	4.92	49.12
17	.0453	1.150620	2050	1.0393	5.16	5.37	6.21	61.93
16	.0508	1.290320	2580	1.3070	4.10	4.26	7.81	78.10
15	.0571	1.450340	3260	1.6512	3.25	3.38	9.87	98.48
14	.0641	1.628140	4110	2.0809	2.58	2.68	12.4	124.2
13	.0720	1.828800	5180	2.6254	2.04	2.12	15.7	156.6
12	.0808	2.052320	6530	3.3064	1.62	1.68	19.8	197.5
11	.0907	2.303780	8230	4.1663	1.29	1.34	24.9	249.0
10	.1019	2.588260	10380	5.2588	1.02	1.06	31.4	314.0
9	.1144	2.905760	13090	6.6281	.809	.833	39.6	380.5
8	.1285	3.263900	16510	8.3626	.641	.660	50.0	479.8
7	.1443	3.665220	20820	10.5456	.508	.523	63.0	605.0
6	.1620	4.114800	26240	13.2913	.403	.415	79.4	762.9
5	.1819	4.620260	33090	16.7572	.320	.329	100	961.9
4	.2043	5.189220	41740	21.1385	.254	.261	126	1213
3	.2294	5.826760	52620	26.6516	.201	.206	159	1530
2	.2593	6.586220	66360	34.0520	.157	.161	201	1929
1	.2893	7.348220	83690	42.3871	.126	.129	253	2432
1/0	.3249	8.252460	105600	53.4609	.100	.102	319	2984
2/0	.3648	9.265920	133100	67.3980	.0795	.0814	403	3763
3/0	.4096	10.43084	167800	84.9683	.0631	.0616	508	4745
4/0	.4600	11.68400	211600	107.1649	.0500	.0512	641	5983

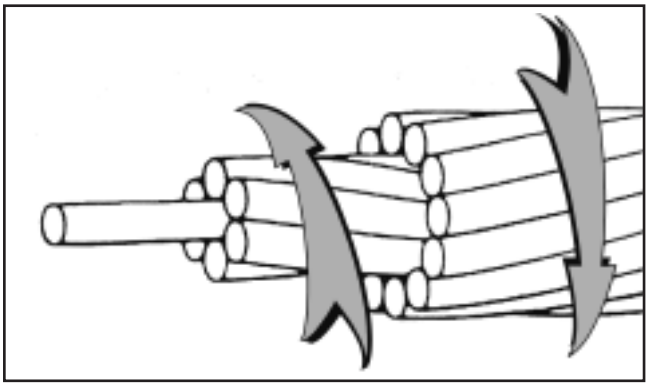
* CMA-Circular Mil Area

Cabling Techniques

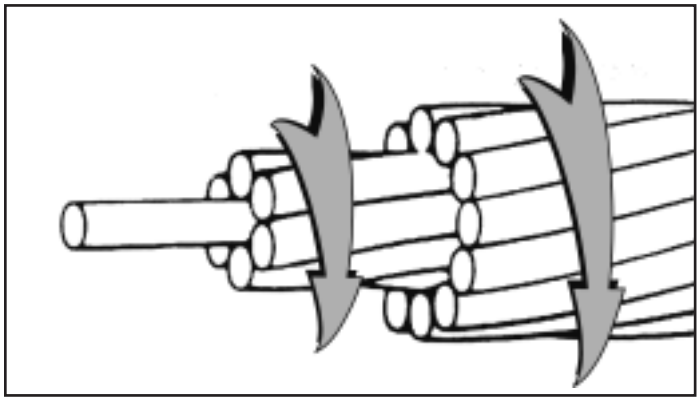
UNILAY or BUNCH: Conductors of any number are twisted together with the same lay direction and cable lay length. Bunch construction will not have a well defined geometric configuration and may have a variable cross-section. A Unilay construction will have a well defined geometric configuration and a defined cross section. This type of cabling technique is usually used on static designs.



CONCENTRIC CONTRA-HELICAL: Conductors that are surrounded by well defined layers of helically laid conductors. Each layer has a reversed lay direction and an increasing lay length in each succeeding layer. This type of cabling technique is usually used on continuous flex designs.



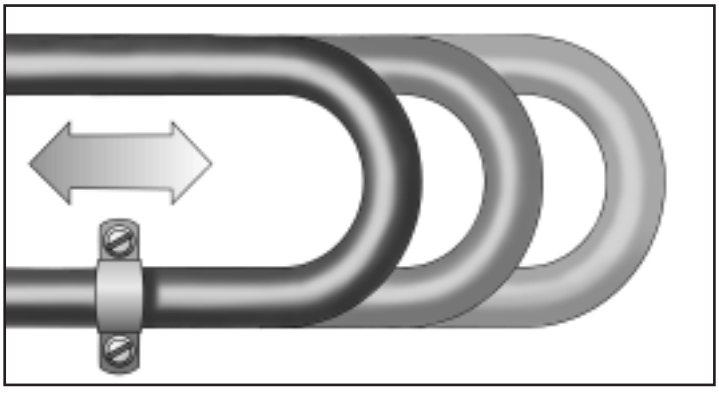
CONCENTRIC UNILAY: Conductors that are surrounded by one or more layers of helically laid conductors with the same direction of lay and increasing lay length in each succeeding layer. This type of cabling technique is usually used on torsional and continuous flex designs.



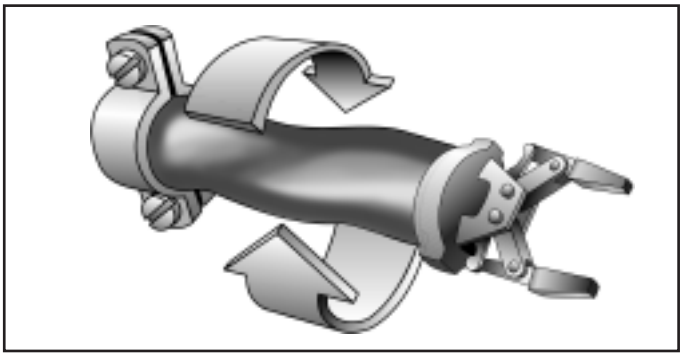
Typical Motions for Flexing Cables

The flex type and application of the cable will determine how the cable is manufactured. When the cable is designed with a special flexing application, the cable has to be manufactured on a unique cabling machine that will minimize any back-twist on the cable core.

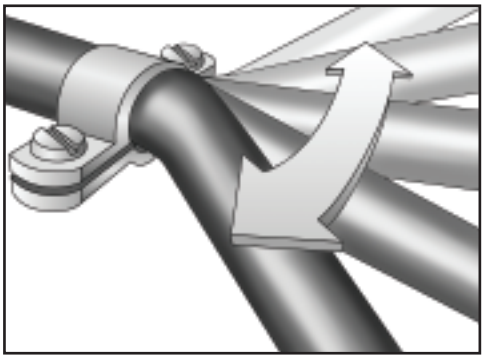
CONTINUOUS FLEX: The cable is rolling/flexing back and forth in a linear motion. Usually these cables are used in C-track applications where the bend radius is designed for 10 x the cable diameter or less.



TORSIONAL FLEX: The cable is twisted clockwise and counter-clockwise with angles varying from 90 to 360 degrees. This type of flexing usually occurs on robotic equipment that is being twisted and flexed constantly for a long period of time.



BENDING FLEX: The cable is flexed back and forth with one of the ends being stationary. This is referred to in the industry as a "tick-tock" motion. The majority of the stress on the cable is on the two focal points where the bend and the load are applied.



National Electrical Code
Allowable Conductor Ampacity

TABLE 310-16

Allowable Ampacities of Insulated Conductors
Rated 0-2000 Volts, 60° to 90°C (140° to 194°F)
NOT MORE THAN THREE CONDUCTORS in Raceway or Cable or Earth
(Directly Buried), Based on Ambient Temperature of 30°C (86°F)

Size	Temperature Rating of Conductor		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
AWG kcmil	TYPES TW†, UF†	TYPES FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW† USE†, ZW†	TYPES TA, TBS, SA SIS, FEP† FEPB†, MI, RHH†, RHW-2, THHN†, THHW†, THW-2, THWN-2, USE-2, XHH, XHHW† XHHW-2, ZW-2
	COPPER		
18	••••	••••	14
16	••••	••••	18
14	20 †	20 †	25 †
12	25 †	25 †	30 †
10	30	35 †	40 †
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430
600	355	420	475
700	385	460	520
750	400	475	535
800	410	490	555
900	435	520	585
1000	455	545	615
1250	495	590	665
1500	520	625	705
1750	545	650	735
2000	560	665	750

TABLE 310-17

Allowable Ampacities of SINGLE INSULATED CONDUCTORS,
Rated 0 through 2000 Volts, In Free Air
Based on Ambient Air Temperature of 30°C (86°F)

Size	Temperature Rating of Conductor		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
AWG kcmil	TYPE TW† UF†	TYPES FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW† ZW†	TYPE TA,TBS, SA SIS, FEP†, FEPB†, MI, RHH†, RHW-2, THHN†, THHW†, THW-2, THWN-2, USE-2, XHH, XHHWT, XHHW-2, ZW-2
	COPPER		
18	....	....	18
16	....	....	24
14	25 †	30 †	35 †
12	30 †	35 †	40 †
10	40 †	50 †	55 †
8	60	70	80
6	80	95	105
4	105	125	140
3	120	145	165
2	140	170	190
1	165	195	220
1/0	195	230	260
2/0	225	265	300
3/0	260	310	350
4/0	300	360	405
250	340	405	455
300	375	445	505
350	420	505	570
400	455	545	615
500	515	620	700
600	575	690	780
700	630	755	855
750	655	785	885
800	680	815	920
900	730	870	985
1000	780	935	1055
1250	890	1065	1200
1500	980	1175	1325
1750	1070	1280	1445
2000	1155	1385	1560

† Unless otherwise specifically permitted elsewhere in this Code, the overcurrent protection for conductor types marked with an obelisk (†) shall not exceed 15 amperes for No. 14, 20 amperes for No. 12, and 30 amperes for No. 10 copper, after any correction factors for ambient temperature and number of conductors have been applied.

For Example:

LAPP USA P/N 221007, 10 AWG, 6 Cond. + 1 ground, 90°C THHN
at 30°C = 40 AMPS x .80 (Adjustment Factor) = 32 AMPS

At 40°C = 40 AMPS X .91 (Temp. Correction Factor) = 36 AMPS
= 36 AMPS X .80 (Adjustment Factor) = 28 AMPS

Adjustment Factors for More than Three Current-Carrying Conductors in a Raceway or Cable. Where the number of current-carrying conductors in a raceway or cable exceeds three, the allowable ampacities shall be reduced as shown in the following table:

Number of Current-Carrying Conductors *	Percent of Values in Tables as Adjusted for Ambient Temperature if Necessary
4 through 6	80
7 through 9	70
10 through 20	50
21 through 30	45
31 through 40	40
41 and above	35

* Does not include ground

TEMPERATURE CORRECTION FACTORS

For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by the appropriate factor shown below.

Ambient Temp. °C	60°C	75°C	90°C
30	1.00	1.00	1.00
40	.82	.88	.91
50	.58	.75	.82
60	....	.58	.71
70	....	.33	.58
80	....	....	.41

Properties of Insulation Materials

Properties	ASTM Method	PVC	Semi Rigid PVC	Polyethylene	Foamed Polyethylene	Polypropylene	Foamed Polypropylene	Polyurethane	HYTREL®	NYLON	TPE
Specific Gravity	D-792	1.15 - 1.68	1.37	0.90 - 1.27	0.55 - 0.61	0.895 - 0.910	0.55 - 0.60	1.00 - 1.20	1.24	1.08	0.90 - 1.29
Tensile Strength, psi	D-638	1500 - 4400	3900	1500 - 2150	540	2800 - 4400	250	>4800	6000	6000	1250 - 2200
Elongation %	D-412	38 - 395	240	175 - 590	165	650	100	530 - 750	490	500	490 - 730
Volume Resisitivity, Ohm-cm	D-257	10^{13} - 10^{16}	10^{14}	>10^{14}	10^{15}	1.5 x 10^{14} 2.8 x 10^{14}	10^{14}	2 x 10^{12} 11 x 10^{12}	10^{10}	10^{12}	2 x 10^{16}
Dielectric Strength, Volts/mil	D-149	240 - 490	390	220 - 1400	290	440 - 830	290	320 - 620	450	460	700
Dielectric Constant @ 1 kHz	D-150	3.7 - 8.1	2.9	2.28 - 2.55	1.7	2.2	1.7	5.7 - 7.7	3.8	4.6	2.8
Power Factor (Dissipation) @ 1 kHz	D-150	0.008 - 0.17	0.0038	0.00049	0.00035	0.0043	0.0034	0.043 - 0.060	0.018	0.045	0.0018
Abrasion Resistance		Good	Excellent	Good	Poor	Poor	Poor	Excellent	Excellent	Excellent	Good
Heat Resistance		Good	Good	Good	Poor	Good	Poor	Good	Good	Good	Good
Weatherability		Good	Good	Excellent	Poor	Excellent	Poor	Good	Excellent	Good	Good
Flame Retardancy		Excellent	Good	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Good
Water Resistance		Good	Good	Excellent	Poor	Excellent	Poor	Good	Good	Fair	Good
Acid Resistance		Good	Good	Good	Fair	Excellent	Fair	Fair	Good	Good	Good
Alkali Resistance		Excellent	Excellent	Good	Fair	Excellent	Fair	Fair	Good	Good	Good
Aliphatic Hydrocarbon Resistance		Good	Good	Poor	Fair	Fair	Poor	Fair	Good	Good	Good
Aromatic Hydrocarbon Resistance		Poor	Poor	Poor	Fair	Fair	Poor	Poor	Good	Good	Good

Properties of Insulation Materials

Properties	Thermoset Neoprene	SBR	KYNAR®	PFA	TEFLON® FEP	TFE
Specific Gravity	1.21 - 1.60	0.92	1.74 - 1.77	2.13 - 2.16	2.13 - 2.16	2.13 - 2.20
Tensile Strength, psi	1175 - 2600	>2800	5000 - 7400	4000 - 4200	2600 - 3000	1100 - 3300
Elongation %	290 - 680	>430	500	300	260 - 320	265
Volume Resisitivity, Ohm-cm	10^{10} - 10^{12}	3 x 10^{15}	2 x 10^{12}	>10^{14}	2 x 10^{16}	>10^{16}
Dielectric Strength, Volts/mil	590	400 - 500	250	480	480 - 550	500
Dielectric Constant @ 1 kHz	4.9 - 7.1	3	7.6	2.2	2.2	2.2
Power Factor (Dissipation) @ 1 kHz	3.6	0.0035	0.019	0.00003	0.0006	0.0002
Abrasion Resistance	Excellent	Good	Good	Fair	Good	Fair
Heat Resistance	Good	Fair	Excellent	Excellent	Excellent	Excellent
Weatherability	Good	Fair	Good	Good	Good	Excellent
Flame Retardancy	Good	Poor	Excellent	Excellent	Excellent	Excellent
Water Resistance	Excellent	Good	Good	Excellent	Good	Excellent
Acid Resistance	Good	Fair	Excellent	Excellent	Excellent	Excellent
Alkali Resistance	Good	Fair	Excellent	Excellent	Excellent	Excellent
Aliphatic Hydrocarbon Resistance	Good	Poor	Excellent	Excellent	Excellent	Excellent
Aromatic Hydrocarbon Resistance	Fair	Poor	Excellent	Excellent	Excellent	Excellent

Teflon® is a registered trademark of DuPont.

Cable Recommendations for Common Coolants Used in Harsh Environments

Fluid Mfg.	Product	90/150/ 190/890/ 891	VFD/ VFD with Signal	VFD Slim U-190, TRAY II UNI 300	855P	890P 891P 900P	490P 492P 590P	CRF	EWKF	SiHF	HAR	SKINTOP® Clamps
		O-PVC	O-PVC	F-PVC	PUR	PUR	PUR	TPE	Silicone	Silicone	Neo	PA
Argent	H-114-LS	G	E	*	E	+	G	+	+	+	+	+
Argent	H-114-M	E	G	*	G	F	G	E	G	*	E	+
Argent	MS-5710-CG	G	E	G	E	+	+	+	+	+	+	+
Argent	MS5710F	E	E	G	G	G	F	E	E	E	E	+
Armour	Lard	E	G	*	G	E	E	+	E	E	*	E
Blaser Swiss	Vasco 1000/Art.2800	E	E	F	E	+	E	+	+	+	+	+
Blaser Swiss	Grindex Univ./Art.882	E	E	G	E	+	E	+	+	+	+	+
Blaser Swiss	Grindex Univ./Art892	F	F	G	G	*	*	E	E	E	E	+
Buckeye	Safe-T-Fluid #4	E	E	*	E	+	E	+	+	+	+	+
Buckeye	Safe-T-Oil #4	E	E	*	G	E	E	E	G	E	E	+
Buckeye	CT9612	E	G	*	E	+	G	+	+	+	+	+
Castrol	WY1-938A	E	G	G	E	+	+	+	+	+	+	+
Castrol	WY3-010C	E	E	*	E	*	G	+	G	F	E	E
Castrol	Syntillo 1023	G	E	G	E	+	+	+	+	+	+	+
Castrol	WS3-020A	G	G	F	E	+	+	+	+	+	+	+
Castrol	Clearedge 6519	E	E	G	G	+	+	+	+	+	+	+
Castrol	Clearedge 6550	G	E	F	G	+	+	+	+	+	+	+
Castrol	Superedge 6768	E	E	*	F	+	+	+	+	+	+	+
Castrol	GTX-SW30- Oil	E	G	*	G	+	+	+	+	+	+	+
Castrol	Type F Transmission	E	E	E	E	+	+	+	+	+	+	+
Castrol	DEXRON III Mercon	E	E	*	E	+	+	+	+	+	+	+
Castrol	Cooledge 8600	E	G	*	*	*	E	G	G	E	E	+
Castrol	Ilogrind FGO Series	E	G	*	F	G	E	E	E	E	E	+
Chem Tech	CT9612 (2)	E	G	F	E	+	E	+	+	+	+	+
Chem Tech	Tech Cool 3404MG	E	G	*	G	E	E	+	E	E	E	E
Chlorox	Sodium Hypochlorite	E	G	G	F	F	F	+	E	E	*	F
Cin. Millicron	Milpro 6000	E	E	*	E	E	E	E	E	E	E	+
Cin. Millicron	Quantalube 270	E	E	*	E	G	G	E	E	E	E	+
CITGO	Citcool 22 Conc.	E	E	*	F	G	G	+	+	E	E	E
CITGO	Citcool 33 Conc.	E	E	E	F	G	G	+	+	E	E	E
CITGO	Sentry 19	E	E	*	G	E	E	+	+	E	G	E
CITGO	Cutting Oil NC 205	E	E	*	*	F	G	+	+	*	*	E
CITGO	Cutting Oil NC 215	E	E	*	F	F	E	+	+	*	*	E
CLC Lubr.	CLC Finish HX-65	E	G	F	E	E	E	+	E	E	E	E
D.A. Stuart	Excelene 420	E	E	*	G	+	+	+	+	+	+	+
D.A. Stuart	Dascool Nobalt KM	E	G	G	G	E	E	E	E	E	E	+
EPP Tech	400 Klear Kool	G	G	F	G	+	+	+	+	+	+	+
Fuchs Lubr.	GK225	E	G	*	G	F	G	G	G	*	G	+
Fuchs Lubr.	Renogrind FG16	G	G	*	F	G	E	+	+	G	F	E
Fuchs Lubr.	CPD 7003	E	E	*	G	E	E	+	+	F	G	E
Fuchs Lubr.	ECOSYN 975 (4%)	E	E	E	E	E	G	E	E	E	E	+
Fuchs Lubr.	ECOSYN 2205 CO	E	E	E	G	G	E	+	+	G	E	E
Fuchs Lubr.	Melsol Supersol	E	G	*	E	G	G	+	F	F	E	E
Fuchs Lubr.	Tuf Draw 2806-M-100	E	E	E	E	E	E	E	E	E	E	+
G-C Lubr.	Kool Grind 900N	E	G	*	F	G	E	+	+	F	F	E
G-C Lubr.	Kool Grind 960	E	E	*	F	E	E	G	E	F	F	E
G-C Lubr.	Aqua Kool PTC	E	G	*	F	F	G	+	+	G	*	E
G-C Lubr.	Aqua Syn 55	E	F	E	G	G	G	+	+	G	E	E
G-C Lubr.	SintoGrind TT	E	E	*	E	E	E	G	E	E	E	+
Hangsterfers	Missie Lube #1XL	G	G	*	G	E	E	+	+	F	G	E
Hangsterfers	Missie Lube #1XXL	G	G	*	G	F	E	+	+	F	E	+
Hangsterfers	Crystal Cut #322	E	G	E	F	F	F	+	+	G	F	+
Hangsterfers	Crystal Cut #322 @5%	E	G	E	E	E	G	+	+	G	G	+
Hangsterfers	R-100	E	E	E	E	E	E	+	E	E	G	E
Hangsterfers	R-100 @ 5%	E	G	E	E	G	E	+	+	E	G	+
Hangsterfers	S500CF	E	E	*	F	G	F	+	G	*	G	E
Hangsterfers	S500CF@10%	E	G	E	G	F	E	+	+	E	G	+
Hangsterfers	Hard Cut 5418	E	E	*	F	G	E	E	E	G	E	+
Hangsterfers	Way Oil #2	G	F	*	G	E	E	+	+	*	E	+

Cable Recommendations for Common Coolants Used in Harsh Environments

Fluid Mfg.	Product	90/150/ 190/ 890/891	VFD/ VFD with Signal	VFD Slim U-190, TRAY II UNI 300	855P	890P 891P 900P	490P 492P 590P	CRF	EWKF	SiHF	HAR	SKINTOP® Clamps
		O-PVC	O-PVC	F-PVC	PUR	PUR	PUR	TPE	Silicone	Silicone	Neo	PA
Hangsterfers	Antiwear 32	G	E	G	G	E	E	+	+	*	E	+
Hangsterfers	Antiwear 66	G	E	G	G	E	E	+	+	*	E	+
Hanilo	171	E	E	*	F	E	E	E	*	*	E	+
Humoco	Iodine	G	G	E	*	E	G	E	E	G	E	+
Itech	CT9612 (3)	E	G	*	E	+	E	+	+	+	+	+
J & J	Mineral Oil	E	G	*	E	E	E	+	F	E	G	E
Lubrisystems	Lubra-Cut UMC	E	E	E	F	G	E	+	+	E	G	+
Master Chem.	Trim O D250	E	G	F	G	F	E	G	G	E	E	+
Master Chem.	Trim VHP E210	E	E	G	*	G	G	E	E	E	E	+
Master Chem.	Trim WB 9303 12 2	E	E	*	E	*	G	G	F	F	E	+
Mobile	Mobile Met Upsilon	G	G	*	G	+	E	+	+	+	+	+
Mobile	DTE 11M	E	E	*	G	G	E	G	E	E	E	+
Mobile	DTE FM 32	E	E	*	E	G	E	G	E	F	E	+
Monsanto	Glacier Motor	E	E	G	G	G	E	E	E	G	E	+
Motorex	SwissCool 7300 CF	E	G	F	F	E	G	+	E	G	E	E
Mullen	1270-4	E	G	*	E	+	E	+	+	+	+	+
NASCO	Acetone	*	*	*	E	F	*	E	E	E	G	+
National Oil	Nocco Grind (11) Conc.)	G	E	*	F	G	E	+	+	G	F	E
National Oil	Nocco Grind (11) (10%)	E	F	E	G	G	G	+	+	E	E	E
National Oil	Nocco Grind 11	E	E	*	E	E	E	G	E	G	E	+
National Oil	Nocco Grind Modl	E	E	*	E	E	E	G	E	G	E	+
Novamax	Circlene#FG 20AMO	G	E	F	E	+	G	+	+	+	+	+
Novamax	Circlene #FG 67	G	G	*	G	+	G	+	+	+	+	+
Quaker	13413	E	E	*	E	+	E	+	+	+	+	+
Rustick	WS-500A	E	E	*	F	F	G	+	+	F	*	E
Solutia	MCS-2638	E	G	*	G	F	G	E	E	E	E	+
Spartan	Carbide Grinder	G	G	F	E	+	E	+	+	*	+	+
Spartan	Synspar GP	G	G	G	G	+	+	+	+	*	+	+
Spartan	Cutter EXP	E	E	G	F	+	+	+	+	*	+	+
STP	Dot 3 Brake Fluid	G	G	F	*	*	*	E	E	E	E	+
STP	Dot 4 Brake Fluid	G	G	G	*	+	+	+	+	+	+	+
Texaco	Rando Oil HD 26	E	E	*	E	G	E	+	+	*	E	+
Texaco	Cleartex D	E	E	*	G	G	E	+	+	E	F	E
Texaco	Oil Coolant Reno 488	E	G	*	F	F	E	+	+	F	*	E
Uni-Pro	Pro Cool 3000	E	G	F	G	*	G	+	E	G	F	E
WD-40	WD-40	E	E	*	G	G	E	E	E	F	E	+
Wesson	Vegetable Oil	E	G	*	F	E	E	+	E	G	G	E
Westmont	Bio-Cool 55	E	G	G	G	E	G	+	E	G	E	E
Yushiro Chem	Yushiron Oil #2	E	E	*	F	G	E	+	+	*	E	+
Zip Strip	Denaturated Alcohol	E	G	*	G	G	E	E	G	E	E	+
Zip Strip	MEK	*	*	*	*	*	*	E	E	E	G	+
Zip Strip	Naphtha	E	E	E	E	E	E	G	E	E	E	+
Zip Strip	Toulene	*	*	*	G	G	G	G	E	E	G	+
Zip Strip	Xylene	F	*	*	G	G	G	G	F	G	G	+
Zip Strip	Turpentine	E	E	*	E	E	E	G	E	E	E	+

E= Excellent (no measurable changes), G= Good (Slight Change), F= Noticeable Change* = Consult Sales Rep for design assistance, + = Not Tested

Note: Lubricating Oils/Coolants, Water Soluble Oils & Emulsions and Commercial Products tested at 60° for 5 days, Paint Solvents tested at 23°C for 5 days.

* If the cable series you need is not listed above, call your Sales Representative for assistance.
(Not all products tested are listed above)

Number Codes

Charts 1, 2 & 3

Conductor	Color	Conductor	Color
1	Black	7	Orange
2	White	8	Yellow
3	Red	9	Purple
*4	Green	10	Gray
5	Brown	11	Pink
6	Blue	12	Tan

Numbers are spaced 20–50 mm apart and are inverted with underline.

* Cables with CE approval have green/yellow conductor for #4

CHART 2: UNITRONIC® 190 & 190 CY, UNITRONIC® FLEX CY

Conductor	Color	Conductor	Color	Conductor	Color
1	Black	22	Black/White/Red	43	Blue/Red/Green
2	White	23	White/Black/Red	44	Black/White/Blue
3	Red	24	Red/Black/White	45	White/Black/Blue
4	Green	25	Green/Black/White	46	Red/White/Blue
5	Orange	26	Orange/Black/White	47	Green/Orange/Red
6	Blue	27	Blue/Black/White	48	Orange/Red/Blue
7	White/Black	28	Black/Red/Green	49	Blue/Orange/Red
8	Red/Black	29	White/Red/Green	50	Black/Orange/Red
9	Green/Black	30	Red/Black/Green	51	White/Black/Orange
10	Orange/Black	31	Green/Black/Orange	52	Red/Orange/Black
11	Blue/Black	32	Orange/Black/Green	53	Green/Red/Blue
12	Black/White	33	Blue/White/Orange	54	Orange/Black/Blue
13	Red/White	34	Black/White/Orange	55	Blue/Black/Orange
14	Green/White	35	White/Red/Orange	56	Black/Orange/Green
15	Blue/White	36	Orange/White/Blue	57	White/Orange/Green
16	Black/Red	37	White/Red/Blue	58	Red/Orange/Green
17	White/Red	38	Black/White/Green	59	Green/Black/Blue
18	Orange/Red	39	White/Black/Green	60	Orange/Green/Blue
19	Blue/Red	40	Red/White/Green	61	Black/Orange/Blue
20	Red/Green	41	Green/White/Blue		
21	Orange/Green	42	Orange/Red/Green		

CHART 3: UNITRONIC® CY PAIRED & UNITRONIC® FLEX CY TP

Pair #	Color	Pair #	Color
1	Black paired with Red	20	White paired with Yellow
2	Black paired with White	21	White paired with Brown
3	Black paired with Green	22	White paired with Orange
4	Black paired with Blue	23	Blue paired with Yellow
5	Black paired with Yellow	24	Blue paired with Brown
6	Black paired with Brown	25	Blue paired with Orange
7	Black paired with Orange	26	Brown paired with Yellow
8	Red paired with White	27	Brown paired with Orange
9	Red paired with Green	28	Orange paired with Yellow
10	Red paired with Blue	29	Purple paired with Orange
11	Red paired with Yellow	30	Purple paired with Red
12	Red paired with Brown	31	Purple paired with White
13	Red paired with Orange	32	Purple paired with Dark Green
14	Green paired with White	33	Purple paired with Light Blue
15	Green paired with Blue	34	Purple paired with Yellow
16	Green paired with Yellow	35	Purple paired with Brown
17	Green paired with Brown	36	Purple paired with Black
18	Green paired with Orange	37	Gray paired with White
19	White paired with Blue		

Color Codes

Charts 4 & 5

CHART 4: UNITRONIC® 300 & 300 CY (24-22 AWG)

Conductor	Color	Conductor	Color	Conductor	Color
1	Black	18	White/Violet	35	White/Red/Orange
2	Brown	19	White/Gray	36	White/Red/Yellow
3	Red	20	White/Black/Brown	37	White/Red/Green
4	Orange	21	White/Black/Red	38	White/Red/Blue
5	Yellow	22	White/Black/Orange	39	White/Red/Violet
6	Green	23	White/Black/Yellow	40	White/Red/Gray
7	Blue	24	White/Black/Green	41	White/Orange/Yellow
8	Violet	25	White/Black/Blue	42	White/Orange/Green
9	Gray	26	White/Black/Violet	43	White/Orange/Blue
10	White	27	White/Black/Gray	44	White/Orange/Violet
11	White/Black	28	White/Brown/Red	45	White/Orange/Gray
12	White/Brown	29	White/Brown/Orange	46	White/Yellow/Green
13	White/Red	30	White/Brown/Yellow	47	White/Yellow/Blue
14	White/Orange	31	White/Brown/Green	48	White/Yellow/Violet
15	White/Yellow	32	White/Brown/Blue	49	White/Yellow/Gray
16	White/Green	33	White/Brown/Violet	50	White/Green/Blue
17	White/Blue	34	White/Brown/Gray		

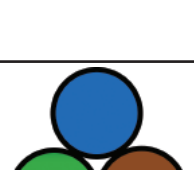
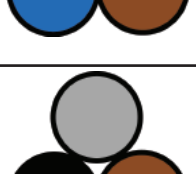
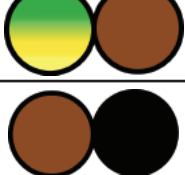
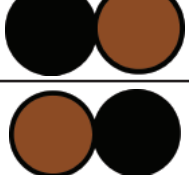
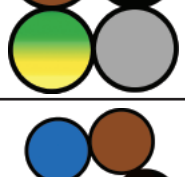
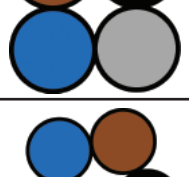
CHART 5: UNITRONIC® 300 & 300 CY (20-16 AWG)

Conductor	Color	Conductor	Color	Conductor	Color
1	Black	18	White/Green	35	White/Red/Red
2	Red	19	White/Yellow	36	White/Red/Green
3	White	20	White/Blue	37	White/Red/Blue
4	Green	21	White/Brown	38	White/Red/Brown
5	Orange	22	White/Orange	39	White/Red/Violet
6	Blue	23	White/Gray	40	White/Green/Black
7	Brown	24	White/Violet	41	White/Green/Red
8	Yellow	25	White/Black/Red	42	White/Green/Green
9	Violet	26	White/Black/Green	43	White/Green/Blue
10	Gray	27	White/Black/Yellow	44	White/Green/Brown
11	Pink	28	White/Black/Blue	45	White/Green/Violet
12	Tan	29	White/Black/Brown	46	White/Blue/Black
13	Red/Green	30	White/Black/Orange	47	White/Blue/Red
14	Red/Yellow	31	White/Black/Gray	48	White/Blue/Green
15	Red/Black	32	White/Black/Violet	49	White/Blue/Blue
16	White/Black	33	White/Black/Black	50	White/Blue/Brown
17	White/Red	34	White/Red/Black		

Color Codes
Charts 6 & 7

CHART 6: VDE 0293

For Flexible and Fixed Installation Cables

# of Conductors	With Green/Yellow Ground DIN VDE 0293-308	Without Ground DIN VDE 0293-308
2		
3		
4		
5		

Flexible Cables built to DIN VDE 0293			Fixed Installation Cables built to DIN VDE 0293
OLFLEX® Classic 100	SPIREX® H07RN-F	OLFLEX® HEAT 180 SiHF	NYM
OLFLEX® Classic 100 Yellow	NSSHOU	OLFLEX® HEAT 180 H05SS-F	HNXMH
OLFLEX® Classic 100 CY	NEOFLEX (flat)	OLFLEX® HEAT 180	OLMASS CY / SY
OLFLEX® 100 H	H05RR-F / H05RN-F / H07RN-F	OLFLEX® HEAT 180 H05SS	OLMASS EB / EB CY
OLFLEX® 105 H	& H05VV-F	EWKF	NYY-J / NYY-O
OLFLEX® SF	NEOFLEX (Round)	OLFLEX® HEAT 180 GLS	NYCY / NYCWY
OLFLEX® 450 P	OLFLEX® Aqua round rubber	OLFLON®-FEP Cables	
OLFLEX® 500P	OLFLEX® Aqua rubber BAM	OLFLON® PTFE / GLS	
OLFLEX® 540 P / 540 CP	KRANEFLEX® NSHTOU		
OLFLEX® 550 P	KRANEFLEX® VS NSHTOU		
SPIREX® 540 P	OLFLEX® Flat Cables		
OLFLEX® PUR S 15 / S 17	OLFLEX® HEAT 145		

CHART 7: DIN 47100 For Paired Cables

(For telephone and electronic use only)

# of Pairs	Color	# of Pairs	Color
1	White paired with Brown	13	White/Black paired with Brown/Black
2	Green paired with Yellow	14	Gray/Green paired with Yellow/Gray
3	Gray paired with Pink	15	Pink/Green paired with Yellow/Pink
4	Blue paired with Red	16	Green/Blue paired with Yellow/Blue
5	Black paired with Violet	17	Green/Red paired with Yellow/Red
6	Gray/Pink paired with Red/Blue	18	Green/Black paired with Yellow/Black
7	White/Green paired with Brown/Green	19	Gray/Blue paired with Pink/Blue
8	White/Yellow paired with Yellow/Brown	20	Gray/Red paired with Pink/Red
9	White/Gray paired with Gray/Brown	21	Gray/ Black paired with Pink Black
10	White/Pink paired with Pink/Brown	22	Blue/Black paired with Red/Black
11	White/Blue paired with Brown/Blue	23-44	Repeat 1-22
12	White/Red paired with Brown/Red	45-66	Repeat 1-22

UNITRONIC® FD CP TP
UNITRONIC® CY PIDY TP
UNITRONIC® LIFYCY TP
UNITRONIC® LIYCY TP
INTERBUS BUS CABLES
PROFIBUS BUS CABLES
MITSUBISHI CCL BUS

The color code for paired cables is in accordance with DIN 47100. At 23 pairs, the identification repeats itself for the first time and from 45 pairs for the second time.

Color Codes

Charts 8 & 9

CHART 8: DIN 47100 (without color repetition)

(For telephone and electronic use only)

UNITRONIC® FD CY, UNITRONIC® FD CP, UNITRONIC® FD 890, UNITRONIC® LIYY, UNITRONIC® LIYCY, UNITRONIC® LIFYCY

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
1	White	17	White/Gray	33	Green/Red	49	White/Green/Black
2	Brown	18	Gray/Brown	34	Yellow/Red	50	Brown/Green/Black
3	Green	19	White/Pink	35	Green/Black	51	White/Yellow/Black
4	Yellow	20	Pink/Brown	36	Yellow/Black	52	Yellow/Brown/Black
5	Gray	21	White/Blue	37	Gray/Blue	53	White/Gray/Black
6	Pink	22	Brown/Blue	38	Pink/Blue	54	Gray/Brown/Black
7	Blue	23	White/Red	39	Gray/Red	55	White/Pink/Black
8	Red	24	Brown/Red	40	Pink/Red	56	Pink/Brown/Black
9	Black	25	White/Black	41	Gray/Black	57	White/Blue/Black
10	Violet	26	Brown/Black	42	Pink/Black	58	Brown/Blue/Black
11	Gray/Pink	27	Gray/Green	43	Blue/Black	59	White/Red/Black
12	Red/Blue	28	Yellow/Gray	44	Red/Black	60	Brown/Red/Black
13	White/Green	29	Pink/Green	45	White/Brown/Black	61	Black/White
14	Brown/Green	30	Yellow/Pink	46	Yellow/Green/Black		
15	White/Yellow	31	Green/Blue	47	Gray/Pink/Black		
16	Yellow/Brown	32	Yellow/Blue	48	Red/Blue/Black		

CHART 9: Color Code for 6 or More Conductors

OLFLEX® 100, 100 CY, 100 SY

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
0	Green/Yellow	26	Violet/Black	52	Trans/Red	78	Beige/White/Blue
1	White	27	Pink/Black	53	Beige/Red	79	Gray/White/Brown
2	Black	28	Orange/Black	54	Pink/Violet	80	Red/White/Brown
3	Blue	29	Trans/Black	55	Orange/Violet	81	Violet/White/Brown
4	Brown	30	Beige/Black	56	Trans/Violet	82	Pink/White/Brown
5	Gray	31	Brown/Blue	57	Beige/Violet	83	Orange/White/Brown
6	Red	32	Gray/Blue	58	Trans/Pink	84	Trans/White/Brown
7	Violet	33	Red/Blue	59	Beige/Pink	85	Beige/White/Brown
8	Pink	34	Pink/Blue	60	Trans/Orange	86	Red/White/Gray
9	Orange	35	Orange/Blue	61	Beige/Orange	87	Violet/White/Gray
10	Transparent	36	Trans./Blue	62	Blue/White/Black	88	Pink/White/Gray
11	Beige	37	Beige/Blue	63	Bwn/White/Black	89	Orange/White/Gray
12	Black/White	38	Gray/Brown	64	Gray/White/Black	90	Trans/White/Gray
13	Blue/White	39	Red/Brown	65	Red/White/Black	91	Beige/White/Gray
14	Brown/White	40	Violet/Brown	66	Violet/White/Black	92	Blue/White/Red
15	Gray/White	41	Pink/Brown	67	Pink/White/Black	93	Brown/White/Red
16	Red/White	42	Orange/Brown	68	Orange/White/Black	94	Violet/White/Red
17	Violet/White	43	Trans/Brown	69	Trans/White/Black	95	Pink/White/Red
18	Pink/White	44	Beige/Brown	70	Beige/White/Black	96	Orange/White/Red
19	Orange/White	45	Red/Gray	71	Brown/White/Blue	97	Brown/White/Violet
20	Trans/White	46	Violet/Gray	72	Gray/White/Blue	98	Orange/White/Violet
21	Beige/White	47	Pink/Gray	73	Red/White/Blue	99	Brown/Black/Blue
22	Blue/Black	48	Orange/Gray	74	Violet/White/Blue	100	Gray/Black/Blue
23	Brown/Black	49	Trans/Gray	75	Pink/White/Blue	101	Red/Black/Blue
24	Gray/Black	50	Beige/Gray	76	Orange/White/Blue		
25	Red/Black	51	Orange/Red	77	Trans./White/Blue		

Color Codes
Chart 10

CHART 10: UNITRONIC® 100 & 100 CY

Sequence of conductors- Basic Colors

Conductor	Color	Conductor	Color	Conductor	Color	Conductor	Color
0	Green/Yellow	3	Brown	6	Green	9	Orange
1	Black	4	Beige	7	Violet	10	Transparent
2	Blue	5	Yellow	8	Pink		

Basic Colors with White Helix

Conductor	Color
11	Red/White
12	Blue/White
13	Yellow/White
14	Green/White
15	Violet/White
16	Orange/White
17	Brown/White

Basic Colors with Red Helix

Conductor	Color
18	Blue/Red
19	Yellow/Red
20	Green/Red
21	White/Red
22	Orange/Red
23	Brown/Red

Basic Colors with Black Helix

Conductor	Color
24	Red/Black
25	Blue/Black
26	Yellow/Black
27	Green/Black
28	Violet/Black
29	White/Black
30	Orange/Black
31	Brown/Black

Basic Colors with Green Helix

Conductor	Color
32	Red/Green
33	Gray/Green
34	Violet/Green
35	White/Green
36	Orange/Green
37	Brown/Green

Basic Colors with Yellow Helix

Conductor	Color
38	Red/Yellow
39	Blue/Yellow
40	Violet/Yellow
41	White/Yellow
42	Brown/Yellow

Basic Colors with Blue Helix

Conductor	Color
43	Red/Blue
44	White/Blue
45	Orange/Blue
46	Brown/Blue

Basic Colors with Violet Helix

Conductor	Color
47	Yellow/Violet
48	Green/Violet
49	White/Violet
50	Orange/Violet
51	Brown/Violet

Basic Colors with Black Helix

Conductor	Color
52	Black/White
53	Black/Yellow
54	Black/Red
55	Black/Green
56	Black/Blue
57	Black/Violet

Basic Color Gray with Colored Helix

Conductor	Color
58	Gray/White
59	Gray/Black
60	Gray/Yellow
61	Gray/Red
62	Gray/Blue
63	Gray/Violet

Basic Colors with Gray Helix

Conductor	Color
64	Red/Gray
65	Blue/Gray
66	Yellow/Gray
67	Green/Gray
68	Violet/Gray
69	White/Gray
70	Orange/Gray

Basic Colors with White/Red Helix

Conductor	Color
71	Blue/White/Red
72	Yel/White/Red
73	Green/White/Red
74	Bwn/White/Red

Basic Colors with White/Black Helix

Conductor	Color
75	White/Black
76	Blue/White/Black
77	Yel/White/Black
78	Green/White/Blk
79	Violet/White/Blk
80	Orange/White/Blk
81	Brown/White/Blk

Basic Colors with White/Green Helix

Conductor	Color
82	Red/White/Green
83	Yel/White/Green
84	Violet/White/Grn
85	Orange/White/Grn
86	Bwn/White/Green

Basic Colors with White/Blue Helix

Conductor	Color
87	Red/White/Blue
88	Yellow/White/Blue
89	Orange/White/Blue
90	Brown/White/Blue

Basic Colors with White/Violet Helix

Conductor	Color
91	Yel/White/Violet
92	Green/White/Violet
93	Orange/White/Blue
94	Bwn/White/Violet

Basic Colors with Red/Black Helix

Conductor	Color
95	Blue/Red/Black
96	Yellow/Red/Black
97	Green/Red/Black
98	White/Red/Black
99	Brown/Red/Black

Basic Colors with Red/Green Helix

Conductor	Color
100	Yellow/Red/Green
101	White/Red/Green
102	Orange/Red/Green

Color Codes
Charts 11 & 12

CHART 11: VDE 0815: Color Code for Industrial Electronics Cable

MARKING:
The conductor of the pairs are marked by the basic colors of the insulating jacket which repeat themselves in the same sequence in each unit.

The units are marked with the colors of the rings on the conductor insulation jacket and the arrangement of the colored rings in groups. The ring groups are spaced approximately 60mm apart.

In cables with more than 12 units, the 13th and subsequent units have colored spirals.

BASIC COLORS OF THE PAIRS:

Pair	1	2	3	4	
a: Conductor	blue	gray	green	white	Counting the units starts with the inner most layer
b: Conductor	red	yellow	brown	black	

Unit	Ring Color	Ring Group	Unit Spiral	Unit	Ring Color	Ring Group	Unit Spiral
1	Pink		-	13	Pink		Blue
2	Pink		-	14	Pink		Blue
3	Pink		-	15	Pink		Blue
4	Pink		-	16	Pink		Blue
5	Orange		-	17	Orange		Red
6	Orange		-	18	Orange		Red
7	Orange		-	19	Orange		Red
8	Orange		-	20	Orange		Red
9	Violet		-				
10	Violet		-				
11	Violet		-				
12	Violet		-				

CHART 12: ICEA S-66-524 NEMA WC-7
Table K-2 with Printed Numbers

Conductor	Color	Print
1	Black	1
2	Red	2
3	Blue	3
4	Orange	4
5	Yellow	5
6	Brown	6
7	Red/Black	7
8	Blue/Black	8
9	Orange/Black	9
10	Yellow/Black	10
11	Brown/Black	11
12	Black/Red	12

Conductor	Color	Print
13	Blue/Red	13
14	Orange/Red	14
15	Yellow/Red	15
16	Brown/Red	16
17	Black/Blue	17
18	Red/Blue	18
19	Orange/Blue	19
20	Yellow/Blue	20
21	Brown/Blue	21
22	Black/Orange	22
23	Red/Orange	23
24	Blue/Orange	24

Conductor 25 is Green/Yellow with no printing.

Color Codes

Charts 13 & 14

CHART 13: UNITRONIC® TP/ TP CY/ TP FY: 20 AWG, 18 AWG, & 16 AWG

Pair #	Colors	Pair #	Colors	Pair #	Colors
1	Black paired with Red	18	Green paired with Yellow	35	Purple paired with Slate
2	Black paired with White	19	White paired with Blue	36	Purple paired with Black
3	Black paired with Green	20	White paired with Brown	37	Slate paired with Red
4	Black paired with Blue	21	White paired with Orange	38	Slate paired with White
5	Black paired with Brown	22	White paired with Yellow	39	Slate paired with Green
6	Black paired with Yellow	23	Blue paired with Brown	40	Slate paired with Blue
7	Black paired with Orange	24	Blue paired with Orange	41	Slate paired with Brown
8	Red paired with Green	25	Blue paired with Yellow	42	Slate paired with Yellow
9	Red paired with White	26	Brown paired with Orange	43	Slate paired with Orange
10	Red paired with Blue	27	Brown paired with Yellow	44	Slate paired with Black
11	Red paired with Yellow	28	Purple paired with Red	45	White/Black paired with Red
12	Red paired with Brown	29	Purple paired with White	46	White/Black paired with Green
13	Red paired with Orange	30	Purple paired with Green	47	White/Black paired with Blue
14	Green paired with Blue	31	Purple paired with Blue	48	White/Black paired with Brown
15	Green paired with White	32	Purple paired with Brown	49	White/Black paired with Yellow
16	Green paired with Brown	33	Purple paired with Yellow	50	White/Black paired with Orange
17	Green paired with Orange	34	Purple paired with Orange	51	White/Black paired with Purple

CHART 14: UNITRONIC® TP/ TP CY/ TP FY: 28 AWG, 26 AWG, 24 AWG & 22 AWG

Pair #	Colors	Pair #	Colors	Pair #	Colors
1	White paired with Black	35	Orange paired with Gray	69	White/Red paired with Green
2	White paired with Brown	36	Yellow paired with Green	70	White/Red paired with Blue
3	White paired with Red	37	Yellow paired with Blue	71	White/Red paired with Violet
4	White paired with Orange	38	Yellow paired with Violet	72	White/Red paired with Gray
5	White paired with Yellow	39	Yellow paired with Gray	73	White/Orange paired with Black
6	White paired with Green	40	Green paired with Blue	74	White/Orange paired with Brown
7	White paired with Blue	41	Green paired with Violet	75	White/Orange paired with Red
8	White paired with Violet	42	Green paired with Gray	76	White/Orange paired with Orange
9	White paired with Gray	43	Blue paired with Violet	77	White/Orange paired with Green
10	Black paired with Brown	44	Blue paired with Gray	79	White/Orange paired with Blue
11	Black paired with Red	45	Violet paired with Gray	80	White/Orange paired with Violet
12	Black paired with Orange	46	White/Black paired with Black	81	White/Orange paired with Gray
13	Black paired with Yellow	47	White/Black paired with Brown	82	White/Yellow paired with Black
14	Black paired with Green	48	White/Black paired with Red	83	White/Yellow paired with Brown
15	Black paired with Blue	49	White/Black paired with Orange	84	White/Yellow paired with Red
16	Black paired with Violet	50	White/Black paired with Yellow	85	White/Yellow paired with Orange
17	Black paired with Gray	51	White/Black paired with Green	86	White/Yellow paired with Yellow
18	Brown paired with Red	52	White/Black paired with Blue	87	White/Yellow paired with Green
19	Brown paired with Orange	53	White/Black paired with Violet	88	White/Yellow paired with Blue
20	Brown paired with Yellow	54	White/Black paired with Gray	89	White/Yellow paired with Violet
21	Brown paired with Green	55	White/Brown paired with Black	90	White/Yellow paired with Gray
22	Brown paired with Blue	56	White/Brown paired with Brown	91	White/Green paired with Black
23	Brown paired with Violet	57	White/Brown paired with Red	92	White/Green paired with Brown
24	Brown paired with Gray	58	White/Brown paired with Orange	93	White/Green paired with Red
25	Red paired with Orange	59	White/Brown paired with Yellow	94	White/Green paired with Orange
26	Red paired with Yellow	60	White/Brown paired with Green	95	White/Green paired with Yellow
27	Red paired with Green	61	White/Brown paired with Blue	96	White/Green paired with Green
28	Red paired with Blue	62	White/Brown paired with Violet	97	White/Green paired with Blue
29	Red paired with Violet	63	White/Brown paired with Gray	98	White/Green paired with Violet
30	Red paired with Gray	64	White/Red paired with Black	99	White/Green paired with Gray
31	Orange paired with Yellow	65	White/Red paired with Brown	100	White/Blue paired with Black
32	Orange paired with Green	66	White/Red paired with Red	101	White/Blue paired with Brown
33	Orange paired with Blue	67	White/Red paired with Orange	102	White/Blue paired with Red
34	Orange paired with Violet	68	White/Red paired with Yellow		

Installation Instructions for Cable Track

INSTALLATION INSTRUCTIONS FOR OLFLEX® CABLE IN CABLE TRACK

1. Only OLFLEX® FD or UNITRONIC® FD cables should be used in a moving cable track application.

2. When selecting cable for cable track, the following criteria must be taken into consideration; environmental conditions such as temperature, chemical influences, indoor or outdoor operation, as well as traveling speed and frequency of operation.

3. The recommended minimum bend radius of the cable should not be exceeded. Refer to the technical data section of this catalog for minimum bend radius for flexing.

4. The cables must be prepared for installation into the cable track without twists, bends or kinks in the cable. Therefore, the cable should always be unwound from the outside layer of the reel or spool. The cable should never be pulled from a coil. Before insertion into the track, it is important that the cable be laid out or hung at least 24 hours prior to installation into the cable track to relax any stresses resulting from transit or storage. If the cable cannot be relaxed, it should be shook out by grasping the cable length at its mid-point and shaking the cable as you move to each end. Then, wrap each end of the cable with masking tape and mark the top of each cable end. **Maintain this alignment throughout installation and clamping.**

5. When placing the cable into the cable track, the track should be laid out flat with the bending direction facing upward, then fitted with the cables in working position. The cables should be laid into the cable track and not weaved between or around other cables. The cables should lay loosely side by side in the track. A minimum clearance of five percent of the cable diameter should be allowed on each side of the cable. When cable is installed in track where spacers are provided, they should be separated from each other.

6. **The cables should not be fixed to the track or tied together in the track.**

7. The weight of the cables must be evenly distributed. Heavier cables should be placed towards the outside of the cable track, while lighter ones should occupy the center of the cable track. When the cable track is side mounted, always place the larger cable towards the outside and the smaller cables toward the inside of the cable track. Cables must not be pulled tight against the inner track curve. Cables must not be pushed tight against the outer track curve.

8. After the cable track is installed, the cables should be cycled through several flexes and observed for freedom of movement. It is important to ensure the cables can move with complete freedom within the bend radius, so that movement of the cables among themselves and with the track is possible.

9. The cables should be clamped into position at both ends of the cable track. Prior to clamping, the alignment marks on the taped ends should be correctly positioned. Do not crush the cables when clamping. The clamping points must be located at a distance of 15 x cable diameter from the end point of the flexing movement. **NOTE: When calculating 15 x cable diameter, it is important to use the diameter of the largest cable in the track.**

North American Regulatory & Safety Standards Agencies

UL "AWM" Recognized Components

Appliance Wiring Material better known under the abbreviation of "AWM" covers wire and cable intended for use as factory installed components of complete equipment. Appliance Wiring Material is not intended for use in direct separate installation in the field. Wire or cable indicating a UL AWM style marking is intended for applications that are unique to each individual style sheet. The usage statement of an individual style sheet will dictate specific end use limitations of the AWM wire or cable. **The NEC does not recognize AWM as an approved wiring method.**

Examples of AWM Use:

If a manufacturer desires to obtain UL Listing for their new piece of equipment they must submit their design to Underwriters Laboratories. The entire UL Listing process will move much more quickly and easily if all internal components used within the equipment design are UL Recognized. If the internal components are not UL Recognized then the UL Listing process will take much longer and cost more as the individual components now must be tested for compliance. AWM can also be used externally to interconnect two UL Listed components such as the data cable assembly that connects a computer to a printer.

UL Listed Wire and Cable Products

Wire and cable covered by this category are intended for use as fixed wiring for the three general building types: residential, commercial and industrial. Listed wire and cable must not only comply with the applicable individual UL standards but also with requirements indicated under specific Articles of the National Electrical Code. The National Electrical Code defines specific end use application and where a particular Listed wire or cable is installed.

Examples of Listed Wire and Cable Use:

A UL Listed wire or cable can be used inside a building where a connection is required from a circuit breaker box to a wall outlet or externally as a coaxial cable when a connection is required from a satellite dish to a television wall receptacle. UL Listed cable can also be used to supply power to a "UL Listed" piece of equipment, such as the flexible cord used in the cord set of your computer or appliance.

C- UL Listing Mark

This marking is represented by a lower case "c" appearing adjacent to the applicable UL symbol and indicate that a wire or cable has been tested by Underwriters Laboratories for conformance to standards from the Canadian Standards Association. These marks are applied to products that are intended for use in the Canadian marketplace.

North American Regulatory & Safety Standards Agencies

C-UL US Classification Mark

UL introduced this new classification mark in early 1998. It indicates compliance with both Canadian and U.S. requirements. The Canada/U.S. Mark is optional. UL encourages those manufacturers with products certified for both countries to use this new combined Mark, but they continue using separate UL Marks for the United States and Canada.

Recognized Component Mark for Canada and the United States

This new UL Recognized Component Mark, which became effective April 1, 1998, may be used on components certified by UL to both Canadian and U.S. requirements. Although UL had not originally planned to introduce a combined Recognized Component Mark, the popularity of the Canada/U.S. Listing and Classification Marks among clients with UL certifications for both Canada and the United States has led to the new mark.

UL Listed Component Mark for Canada and the United States

This Listing mark was introduced by UL in early 1998. This mark indicates compliance with both U.S. and Canadian requirements. The use of the combined Canada/U.S. UL mark is optional. UL encourages manufacturers with products certified for both countries to use this mark, but they may continue using separate UL Marks for Canada and the United States.

General Information

The local or state office of the Electrical inspector dictates regulations governing cables that are installed in conduit. These regulations can vary or fluctuate depending upon interpretation of the National Electrical Code in different states and local municipalities.

Canadian Standards Association (CSA)

Lapp USA offers the following type of Wire and Cable Certified by the Canadian Standards Association on a wide variety of different products.

Appliance Wiring Material (AWM) refers to wire and cable that is manufactured per the requirements specified in CSA Standard C22.2 No.210. AWM Wire and Cable is intended to be used internally within electrical and electronic equipment and can also be used for external interconnection between equipment. C22.2 No.210 defines AWM categories as follows:

Class I Internal
Group (A) – Where not subjected to mechanical abuse
Group (B) – Where may be subjected to mechanical abuse

(1) Wet Location
(2) Oil Resistant

Class II External
Group (A) – Where not subjected to mechanical abuse
Group (B) – Where may be subjected to mechanical abuse
(1) Wet Location
(2) Oil Resistant

In order to comply with CSA Certification requirements all AWM wire and cable must pass one of the following flame tests*

ER- Exposed Run Approval

In order to comply with CSA Certification requirements all AWM wire and cable must pass one of the following flame tests*

FT1 – This vertical flame test procedure is specified under CSA Standard C22.2 No. 0.3 and requires that any wire or cable must not propagate a flame or continue to burn for more than one minute after five, fifteen-second applications of flame. The flame source is removed for fifteen seconds in between flame applications.

FT2 - This horizontal test procedure is also specified under CSA Standard C22.2 No. 0.3 and requires that any wire or cable must self-extinguish after one 30-second application of flame. Any burning particles falling from the test specimen cannot cause the cotton covering the enclosure floor to ignite.

FT4 - This vertical test procedure is also specified under CSA Standard C22.2 No. 0.3 and used to determine the flame propagation tendency of cables in a vertical tray. While this test is similar to the UL Vertical Tray Flame test specified under UL Standard 1581, FT4 differs in severity. The FT4 test requires mounting of the burner to be at 20° from the horizontal with its burner ports facing up. The UL Vertical Flame test requires positioning of the burner at 0° from the horizontal. The allowable cable char length for the FT4 flame test is only 4.92 ft, where UL 1581 permits eight feet maximum of damage.

* Note: The flame tests indicated above are brief descriptive summaries only, for complete details regarding specific test procedures and requirements, please refer to the applicable CSA standards. The Chart on Page 655 explains how Lapp cables are categorized.

Exposed Run for Tray Cables

Type TC-ER: 600V
2008 NEC Article 336.10 (7) indicates that in Industrial establishments, Type TC Tray cable that complies with the crush and impact requirements of Type MC (Metal Clad) cable and is identified for such use with the marking Type TC-ER shall be permitted between a cable tray and the utilization equipment or device. The cable shall be secured at intervals not exceeding 1.8 m (6 ft). Please refer to NEC Article 336.10 (7) for more specific information.

Type PLTC-ER: 300V
2008 NEC Article 725.154 (E) (7) indicates that in industrial establishments Type PLTC cable that complies with the crush and impact requirements of Type MC (Metal Clad) cable and is identified for such use shall be permitted to be exposed between the cable tray and the utilization equipment or device. The cable shall be secured at intervals not exceeding 1.8 m (6 ft). Please refer to the NEC Article 725.154 (E) (7) for more specific information.

LAPP NEC Doppler for Use in Cable Tray Applications

LAPP Products		–	OLFLEX® POWER MULTI	–	–	–	–	UNITRONIC® 190 UNITRONIC® 300	UNITRONIC® 300	OLFLEX® Tray II OLFLEX®TC 600 OLFLEX® CONTROL TM OLFLEX® CONTROL M OLFLEX® AUTO X & I, VFD	–
UL Cable Types	Plenum					FPLP	CATVP	CMP	CL3P, CL2P		OFCP
	Riser					FPLR	CATVR	CMR	CL2R, CL2R		OFCR
	General	CT	STOOW	PLTC	MC, MI, ITC-HL	FPL	CATV	CMG, CM, DP-1	ITC, PLTC, CL3/2	TC, TC-ER	OFCG, OFN
Article	Type of Article	Voltage	Hook-up	Cordage	Thermocouples	Armored	Fire Alarm	Coaxial	Data Cables	Control Cables	Power Cables	Fiber Optic
330	Metal Clad: Type MC	600V 2000V				X						
332	Mineral-Insulated Metal Sheathed Cable	300V 600V				X						
336	Power and Control Tray Cable	600V 2000V				X					X - ER*	
392	Cable Trays*	150V 2000V	X ≥ 1/0 AWG	X TC / STOOW**	X*	X*	X*	X*	X*	X*	X*	X*
400	Flexible Cords and Cables	300V 600V		X Portable							X* Class 1, Div. 2	
500 501	Hazardous Locations & Class 1 Locations	150V 2000V		X - Portable Class 1, Div. 1	X Class 1, Div. 2	X Class 1, Div. 1				X Class 1, Div. 2	X Class 1, Div. 2	
645	Data Processing	150V 2000V	X - (GND) ≥ 4 AWG		X	X	X	X	X	X	X	X
725	Power Limited Tray Cables	300V			X				X	X - ER 300V - PLTC		
727	Instrumentation Tray Cables	150V								X 150V - ITC		
760	Fire Alarm Systems	300V					X		X			
770	Optical Fiber Cables and Raceways	N/A										X
800	Communications Circuits	300V							X	X No - PLTC		
820	Community Antenna Television and Radio							X	X			

* - *Different voltage rated cables may be installed in the same tray provided that cables ≤ 600 volts are separated by a divider from cables > 600 volts.*

** - ***UL Dual Rated***

ER - Exposed Run, supported every 6 feet

9/6/07

NEC Doppler for Use in Cable Tray Applications

International Regulatory Agencies

International Safety Standards Agencies

Most countries have their own standards writing agencies. However, the basis for the majority of International standards are adaptations from, or exact duplication of publications from the following Safety Standard Agencies. These Standards Agencies are commissioned to create and publicize International Safety Standards. They are standards setting agencies only. The enforcement of and testing to these standards is undertaken at the national level, but the final interpretation of design and approval of the product always lies with the National Test Agencies.

IEC (International Electrotechnical Commission)

The IEC is composed of representatives from manufacturers, users, and national testing labs from many of the European industrialized nations. Their primary directive is to publicize recommendations for safety standards. Although IEC publications do not have the force of law, in most cases new standards published by the National Testing Agencies in Europe and Australia have only minor deviations from IEC publications.

CEE (International Commission for Rules for the Approval of Electrical Equipment)

CEE was composed of representatives from European National Testing Labs. The CEE's work has been taken over by CENELEC.

CENELEC (European Committee for Electrotechnical Standardization)

The primary responsibility of CENELEC is to develop electrotechnical standards which represent a consensus among its European member countries. While IEC publications are generally the basis for European National Standards, CENELEC will cover matters which its members feel are not completely addressed by IEC documents.

National Testing & Approval Agencies

Although a product may have been designed to comply with individual standard agencies, or with IEC, CEE or CENELEC, each product *must* be tested, approved and marked by the National Testing Agency for each country the cords are to be sold in (such as VDE, SEMKO, DEMKO, etc.) In most cases it is illegal to sell non-approved products.

Australia - ETSA (Electricity Trust of South Australia)

There are six electrical testing agencies in Australia. Generally, an approval with one of the agencies is accepted by the others. The Standards Association of Australia (SAA) is the recognized association for the preparation of Australian standards. SAA's policy is to use IEC standards as its guidelines. The SAA mark molded into a plug or connector indicates that a product has been tested and approved by one of the Australian testing agencies and SAA. Australian agencies require that an approval number be molded into the plug and connector. The cordage itself is the same used in Europe.

Austria - OVE (Austrian Association for Electrical Technology)

OVE is the standards association and the National Testing Agency. IEC standards are the basis for OVE standards. The OVE mark molded into a plug or connector indicates that a product has been tested and approved for use in Austria.

Belgium - CEBEC (Belgium Electrotechnical Committee)

The recognized association for Belgian standards is the Belgium Electrotechnical Committee (CEB). The range of CEB standards is similar to IEC. The CEBEC mark molded into a plug or connector indicates that a product has been tested and approved by CEBEC for use in Belgium. CEBEC approval in Belgium is voluntary.

Canada - CSA (Canadian Standards Association)

CSA is one of five accredited standards writing organizations in Canada. Unlike other foreign countries, Canada does not have separate standards and national testing agencies. The CSA mark indicates that a product has been tested and approved for use in Canada.

United States - UL (Underwriters Laboratories, Inc.)

Underwriters Laboratories, Inc., is chartered to establish, maintain, and operate laboratories for the examination and testing of devices, systems and materials to determine their relation to hazards to life and property, and to ascertain, define and publish standards, classifications and specifications for materials, devices, products, equipment, constructions, methods and systems affecting such hazards.

International Regulatory Agencies

Denmark—DEMKO (Danish Electrical Testing Station)

The recognized association for Danish standards is the Danish Electrotechnical Committee (DEK). DEK adopts CENELEC and IEC standards as their basis for standards. The DEMKO mark molded into a plug or connector indicates that a product has been tested and approved by DEMKO. Goods not bearing this mark cannot be sold in Denmark.

Finland—SETI (Electrical Inspectorate)

The recognized association for Finnish standards is the Finnish Electrotechnical Standards Association (SESKO). Most of the standards set by SESKO are in accordance with IEC and CENELEC publications. The SETI mark molded into a plug or connector indicates that a product has been tested and approved by SESKO and SETI for use in Finland. Use of this mark is mandatory only on equipment used in homes, offices, shops & other premises where the public is admitted.

Germany—VDE (Association of German Electrical Engineers)

The recognized association for German standards is the German Electrotechnical Commission of DIN & VDE (DKE). The DKE standards are identical to IEC standards. The VDE mark indicates that a product has been tested and approved by DKE and VDE.

Italy - IMQ (Italian Institute of the Mark of Quality)

The recognized association for the preparation of Italian standards is the Italian Electrotechnical Committee (CEI). The basis of CEI standards is the IEC and CENELEC standards. The IMQ mark on the plug or connector indicates that a product has been manufactured according to CEI standards. There is no legal authority for the mandatory application of standards in Italy.

Netherlands - KEMA

The recognized association for standards in the Netherlands is the Netherlands Electrotechnical Committee (NEC). The NEC adopts IEC standards with few deviations. The KEMA mark on the plug or connector indicates that a product has been tested and approved by NEC and KEMA. The use of electrotechnical standards is voluntary in the Netherlands.

Norway - NEMKO (Norwegian Board for Testing and Approval of Electrical Equipment)

The recognized association for Norwegian standards is the Norwegian Electrotechnical Committee (NEK). NEK standards are identical to IEC and CENELEC. The NEMKO mark molded into a plug or connector indicates that a product has been tested and approved by NEMKO.

Sweden - SEMKO (Swedish Institute for Testing and Approval of Electrical Equipment)

The recognized association for Swedish standards is the Swedish Electrical Commission (SEK). There are more than 800 Swedish electrical standards. Most of them are identical to IEC standards. Most of the standards are voluntary. However, domestic electrical equipment is subject to approval and cannot be sold unless approved by SEMKO. The SEMKO mark molded into a plug or connector indicates that a product has been tested and approved by SEMKO.

Switzerland - SEV (Swiss Electrotechnical Association)

The recognized association for Swiss standards is the Swiss Standards Association (SEV). The SEV has adopted IEC standards almost without exception. The SEV mark molded into a plug or connector indicates that a product has been tested and approved for use in Switzerland. All products to be sold in Switzerland must bear this mark.

European agencies require the agency marking to be molded into the plugs and connectors. There are two alternatives for marking cordage. The manufacturer's name and the National Test Agency symbol are printed on the blue primary conductor. In addition to the primary conductor marking, the symbol for CENELEC—"HAR"—can be printed on the outer jacket. According to CENELEC and the national approval agencies, the "HAR" symbol is not mandatory as long as a National Test Agency symbol is on the cordset. The product is fully approved for use in any Continental European country as long as it is manufactured to CENELEC and foreign agency standards and carries one of the above markings.

TUV SUD Group is a global, independent testing laboratory. The range of services TUV provides includes consulting, inspections, tests, and expert opinions, as well as certification and training on global norms.

VFD Cable Selection Guide

Motor Properties
AWG Size Selection Chart Per NEC

DRIVE HP	230 V 3ø AWG	460 V 3ø AWG	575 V 3ø AWG	DRIVE HP	230 V 3ø AWG	460 V 3ø AWG	575 V 3ø AWG
1/2 - 3	14	14	14	60	4/0	1	2
5	14	14	14	75	300 KCMIL	1/0	1
7 1/2	10	14	14	100	500 KCMIL	3/0	1/0
10	8	14	14	125	*	4/0	3/0
15	6	10	12	150	*	300 KCMIL	4/0
20	4	8	10	200	*	500 KCMIL	300 KCMIL
25	2	6	8	250	*	*	500 KCMIL
30	1	6	8	300	*	*	*
40	2/0	4	6	350	*	*	*
50	3/0	2	4	400 - 500	*	*	*

Note: The above table references the suggested wire AWG to use based on Horse Power (HP) and the Full Load Current (FLC) times 125% per NEC Art. 430-122 (A). Amperes (FLC) were determined from NEC Art. 430-250:

For Example: For a 5 HP and 460 Volt motor, the FLC is 7.6A x 125% = 9.5A. The right AWG wire for 9.5A is 14 per NEC Art. 310.15. See page 667, for Table 310.15(B)(16).

VOLTAGE DROP FACTORS, VOLTS AT FLC @ 20˚C

DRIVE HP	230 V 3ø AWG	460 V 3ø AWG	575 V 3ø AWG	DRIVE HP	230 V 3ø AWG	460 V 3ø AWG	575 V 3ø AWG
1/2	.017	.008	.007	30	.020	.032	.042
3/4	.025	.012	.010	40	.021	.027	.033
1	.032	.016	.013	50	.023	.020	.026
1 1/2	.046	.023	.019	60	.016	.019	.018
2	.052	.026	.021	75	.012	.020	.019
3	.074	.037	.030	100	.011	.022	.021
5	.050	.058	.046	125	.008	.047	.022
7 1/2	.047	.058	.069	150	.008	.041	.015
10	.036	.072	.084	200	.006	.011	.013
15	.034	.045	.053	250	N/A	.010	.011
20	.028	.038	.047	300	N/A	.008	.009
25	.020	.028	.036	350	N/A	.008	.009

Note: The above table references the voltage drop over distances. It was determined by using selection criteria of Motor Properties Table. In order to determine the voltage drop, multiply the length by the data above.

For Example: For a 5 HP and 460V motor, P/N 701404 would be used. For a distance of 200 feet, your voltage drop would be 200 x .058 = 11.6volts.

In keeping with the principles of the Lapp Group, customer education is at the top of the list. We strive to keep our customers aware of breaking industry changes. For a more detailed technical explanation, please visit Lapp USA's website at www.lappusa.com/vfd-whitepaper.pdf.

Voltage Designations

Nominal Voltage- The characteristic operating voltage of a wire or cable that is referenced to define its electrical rating.

The nominal voltage in European applications is expressed by the combination of two values expressed by the designations Uo/U, where:

Uo: The voltage between any insulated conductor and shield or ground.
U: The voltage between any two conductors of a multi-conductor cable.

Nominal Voltage Example:

P/N 0026157- The nominal voltage is expressed as 300/500 V.

Uo: 300 V, voltage between any insulated conductor and shield ground.
U: 500 V, voltage between any two conductors of a multi-conductor cable.

Voltages are expressed in terms of Alternating Current (AC). A conservative estimate of the amount of Direct Current (DC) voltage is 1.5 times the AC Value.

Direct Current Example:

P/N 0026157- Based on the voltage listed above, the estimated DC voltage would be as follows:

Uo: 300 Vac x 1.5 = 450 Vdc
U: 500 Vac x 1.5 = 750 Vdc

ATEX

Electric Systems in Areas with Risk of Explosions- Directive 94/9/CE (ATEX)

The ATEX directive (directive 94/9/CE) applies to all products for systems designed to be used in explosive atmospheres.
ATEX stands for:

AT= Atmosphere EX= Explosive 94/9/CE (year, no., European Community). It defines the requirements for protecting the safety and health of people, pets and property, and states the various procedures to be followed for demonstrating the conformity of devices to the directive's requirements.
An “explosive atmosphere” means a mixture of air and flammable substances (gas, vapors, mists or dusts) at ambient temperature and pressure, which rapidly spreads combustion when it comes in contact with a source of ignition.

Components conforming to the above safety requirements should be used in all areas classified as hazardous in terms of the risk of explosion due to the presence of gases or dusts. The risk is divided into three levels, each of which have a particular construction category:

- Category 1 covers the level of maximum risk (areas 0 to 20)
- Category 2 covers the highest risk level (areas 1 and 21)
- Category 3 covers the “normal” risk level (areas 2 and 22). The definition “normal” has not been given by chance, as all community laws impose the maximum possible levels of prevention against the formation of explosive atmospheres, so that only areas 2 and 22 should exist in normal conditions.

A number of different methods of protection can be employed. The protection method used should be clearly marked on the device. ATEX SKINTOP® conform to protection method “e” (increased safety) which consists in taking provisions intended to prevent the formation of hot spots.

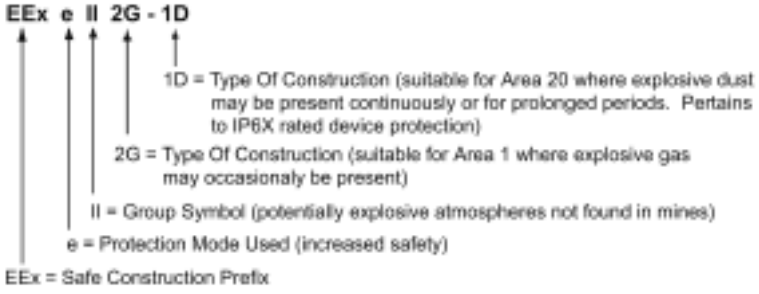
Protection modes
Ex n
Protection method Ex n is fundamentally based on provisions for prevention and is divided into two main categories.

The category applicable to SKINTOP® is: EEx nA applicable to non-sparking appliances, namely those that do not produce arcs, sparks or hot spots during normal operation (junction and connector boxes, fuse holders, lighting appliances, etc.). The nA category bases the protection criteria on increased safety provisions. Those that apply to SKINTOP® are as summarized below:

- protection levels suitable for the environment
- possible loss-proof gaskets
- recommended minimum resistance of the enclosure to impacts: 5J (>IK08)
- resin housings with adequate resistance to temperature and surface current effects
- the maximum temperature of any surface in contact with the outside air must not exceed the limits applicable to the temperature class

ATEX Compliance Marking

ATEX compliant products must be clearly marked to show the specifics of the compliance. Products may be marked in several different ways. There can be a combined gas/dust marking, or gas and dust can be done separately. A combined mark for ATEX SKINTOP® would be:
ATEX markings may also be shown separately for gas and dust and may use the ATEX construction symbol instead of the prefix.



An example of the above listing in this alternate presentation is shown below:

Connector Technical Data

EPIC® Overview

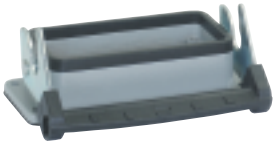
The most important considerations for a heavy duty connector are its electrical characteristics, its mechanical characteristics and the materials from which it is manufactured. The heavy duty connector provides safe connection and disconnection of electrical power or signals with robust housings which are suitable for hostile environments (connectors should never be mated or unmated under load.)

The construction of a rectangular connector can be selected specifically for a customer's requirement. EPIC® industrial connectors from Lapp are made up of various components (housings, inserts, contacts, strain relief.)

The various components of the heavy duty rectangular connector are purchased individually and made up on a modular principle. A wide range of housing sizes and many options of inserts and contacts make it possible to design the ideal connector for each application.

HOUSINGS

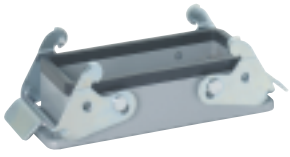
Hood:
A hood may have a top or an angle (side) entry of different PG, Metric, or NPT sizes to accommodate a wide range of cable diameters. The hood can be mated with either a surface or panel mounting base, or a cable coupler hood (for cable to cable connection.)



Panel Mount Base Housings:
The panel base is wired from below through a hole cut in a panel. The panel base is attached to the surface of a control panel for connection of control or power cables.

Surface Mount Base Housings:
The surface base is a complete enclosure only offering cable entry through a cable gland mounted either on one or both sides of the base.

Cable Coupler Hood:
The cable connector mates with a top entry hood to offer cable to cable connection. This is frequently used to extend cables.

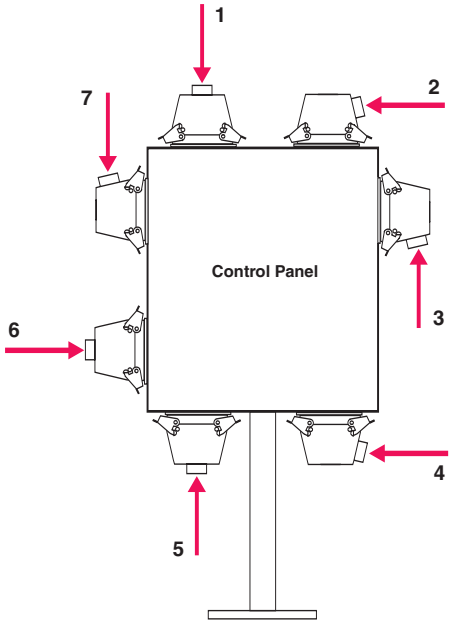


Fixed Locking Lever (Latches) types:
There are two types of locking levers:
- Single locking lever which bolts on the longer side of the connector
- Double locking lever which bolts two levers on the shorter sides of the connector.
- Hoods or Bases can feature single or double levers.

Connector Technical Data

How to Choose Connector Housings

TOP VS. SIDE ENTRY HOODS



"There is no right or wrong"- The goal is to match the hood entry to the installation requirement as closely as possible.

Choose your housing by answering these two questions:
1. Where are you mounting the connector?

2. Where is the cable coming from?

This will allow you to make a reasonable selection.

Example	Hood Entry Location	Panel Surface where connector is Mounted	Cable Entry Direction
1	Top	Top	Vertical down from above
2	Side	Top	Horizontal from side
3	Side	Side	Vertical up from below
4	Side	Bottom	Horizontal from side
5	Top	Bottom	Vertical up from below
6	Top	Side	Horizontal from side
7	Side	Side	Vertical down from above

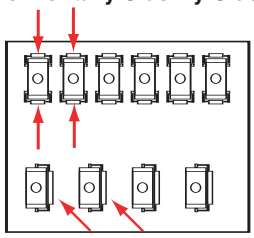
SINGLE VS. DOUBLE BOLT HOODS

Although either bolt location can be used, the key is to use a bolt location that allows the connectors to be mounted as close together as possible while providing the maximum access possible to the locking levers on the base.

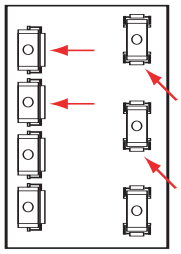
For connectors mounted horizontally side by side, the double bolt location is preferred.

For connectors mounted vertically top-to-bottom, the single bolt location is preferred.

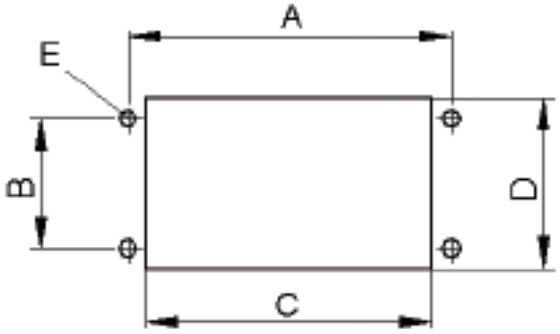
Connectors Mounted Horizontally Side-By-Side



Connectors Mounted Vertically Top-To-Bottom



PANEL CUT OUT SIZE



Panel cut out for panel mount base (mm):

	A	B	C	D	E
HA 3	30	-	21	21	3.3
HA 10	70	17.5	57.5	24	3.6
HA 16	86	17.5	73.7	24	3.6
HA 32	92	42	74.2	48.4	4.3
HA 48	110	65	85.5	71	5.5
HA 64	148	70	117	82	7
HBE 6	70	32	52.2	35	4.3
HBE 10	83	32	65.2	35	4.3
HBE 16	103	32	85.5	35	4.3
HBE 24	130	32	112.2	35	4.3
HBE 32	110	65	85.5	71	5.5
HBE 48	148	70	117	82	7

Connector Technical Data

Plugs & Receptacles (Male & Female Inserts) Overview

The male and female inserts are the receptacles for the male (pins) and female (sockets) contacts respectively, and are the interface for the electrical connection. Cable is terminated to the contacts. Inserts provide the electrical insulation.

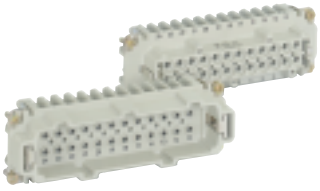
SCREW TERMINATED PLUGS & RECEPTACLES

This simple type of termination is distinguished by its ease of maintenance. No special tool is required, just a screwdriver to undo and tighten up the terminal screws.

Screw connection technology (as per DIN EN 60999):

Conductor section (mm2)	1	1.5	2.5	4	5	10
Screw Thread	M 2.6	M 3	M 3	M 3.5	M 4	M 4
Recommended Ncm	40.7	50	50	80	120	120

CRIMP TERMINATED PLUGS & RECEPTACLES



The purpose of crimping is to produce a good mechanical, electrical, and gas-tight connection. This should remain unchanged with regard to quality in the long-term, and should thus be reliable. Crimping also reduces termination time and allows the designer to achieve more connections than screw termination would permit in the same space.

Hand operated tools or crimping machines can be used to assemble crimp contacts. The following points must be followed in order to obtain the ideal crimping result:

- Cross section dimension/ gauge size and structure of the cable
- Contact type and size
- Tool and tool setting

Stamped & Formed Contacts

There are two different crimp contact types: machined and stamped and formed. These two types of contacts have differing characteristics in terms of quality and how the termination is made.

Stamped & Formed Contacts: The crimping sleeve allows a wider range of wire gauges to be crimped. This guarantees reliable crimping quality. Furthermore, the insertion and extraction force is usually lower with stamped pin and socket contacts. This is achieved by the large contact area and the spring characteristics of the stamped contact's material. Stamped contacts can be supplied reeled for use with automatic feed crimping tools.

Machined Contacts

Machined Contacts: With this popular type of contact, the suitable contact size is matched to the wire gauge of the cable. The correct crimping tool or dies must be used.

SCREWLESS SPRING CAGE CLAMP INSERTS

This type of termination is noted for its ease and speed of fitting without an additional tool. The compensating effect of the cage clamp enables good contact to be maintained in the long term.

MODULAR SERIES

7 Module Frame in a Hood

The Modular series inserts provide flexibility. A combination of 2 or up to 14 Modules can be combined into one connector housing. The available modules include coax, high voltage, cage clamp and crimp terminated.

# of Contacts: 2 up to 280

Connector Technical Data

General Approvals/ Design Specifications

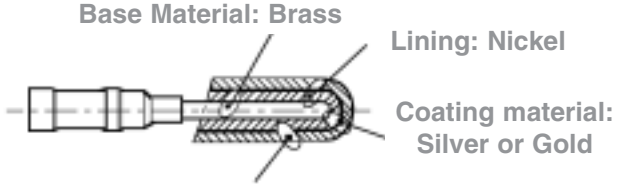
General Design: EPIC® connectors consist of mating male and female inserts of various sizes and electrical characteristics which utilize either screw-clamp, crimp contacts or cage clamp terminations. The inserts are fully enclosed in hoods and housings of either plastic or metal.

Termination:
Screw-Clamp: Screw-clamp insert contacts are made of copper alloy and plated with silver to inhibit corrosion. Clamping and fixing screw are made of galvanized steel with a yellow chromate plating.

Cage-Clamp: Cage-clamp insert contacts are made of copper alloy. The cage-clamp screwless spring termination requires no special tools for termination. The connection is vibration proof and never require re-tightening.

Crimp-Contact: Crimp-contact inserts shall accept either stamped and formed or machined crimp contacts. Crimp contacts feature a base crimp contact and a stainless steel locking spring. Crimp contacts are made of a copper zinc alloy, plated with an appropriate material (tin/lead, gold or silver) to provide corrosion resistance.

Hoods and Bases: Hoods and bases are made of either metal or plastic depending on the application requirement. Metal hoods are made of an anodized aluminum cast material for corrosion resistance. Additionally, metal hoods and bases feature a powder-paint surface for wear resistance. Thermoplastic housings are heat resistant for high temperature applications.



Contact Material Details:
The coating of the base material with a precious metal is necessary to guarantee a long lasting and good connection. The contacts are plated normally by galvanic processes. To reach a long-lasting plating, there are some requirements for the contact and the plating material.

Requirements on contact material:
- Good dimensional stability
- High corrosion resistance
- Good electrical conductivity

Brass (copper zinc alloy) is used for its good mechanical properties and its electrical conductivity. Because it is also relatively economical, it has become one of the most preferred contact materials.

Requirements on contact coatings:
- High abrasion resistance
- Low contact resistance
- High corrosion resistance
- Low porosity
- Good coat formation
- Solderability

Silver or gold are the normal choice for surface coating.

Silver possesses the highest electrical conductivity of any metal and is the most cost-effective precious metal. With sulphur or sulphurous products in the ambient air, a brownish to black oxide coating made up of silver sulfide (Ag2S) will rapidly be formed. However, this coating will break up in the process of mating and will be broken down by high currents, so that the necessary electrical conductivity is maintained. Passivation of the silver surface will delay the formation of the oxide coating and will reduce the mating and unmating forces.

Gold is the most tarnish resistant precious metal. Formation of oxides and sulphides can be discounted. Gold contacts are distinguished by their low mating and unmating forces. They are mainly used for transmission of signals with low current and voltage values.

Alternative materials for surface coating:
Nickel is normally applied as a corrosion protection and blocking layer. Furthermore, the relatively high hardness of the Ni coating has a positive effect on wear characteristics.

Tin or Tin/Lead is one of the most frequently employed metals for contacts, especially in the automotive field. As an aid to soldering, virtually all partially coated strips in the connection are coated with tin or tin/lead. Due to the low hardness of tin, the mating forces are very high and this makes it unsuitable for connectors that are designed for a high number of mating cycles.

Pollution:
Numerical value which states the anticipated pollution in the micro environment.

Pollution level 1:
No pollution or only dry, non-conductive pollution occurs. This pollution has no influence. **ex.** Open, unprotected insulations in air-conditioned or clean dry rooms.

Pollution level 2:
Only non-conductive pollution occurs. Occasionally, however, it may be anticipated that transient conductivity arises due to condensation. **ex.** Open unprotected insulations in residential, commercial or business premises (fine mechanical engineering workshops, laboratories, test areas, rooms used for medical purposes).

Pollution level 3:
Conductive pollution arises, or dry, non-conductive pollution which becomes conductive because condensation has to be anticipated. **ex.** Open unprotected insulations in rooms of industrial, commercial and agricultural companies, unheated storage rooms, boiler houses and workshops.

Pollution level 4:
Contamination leads to continuous conductivity caused by condensation or other environmental contaminants.

ex. External exposed installation subject to all environmental changes. Pollution level 3 is typical for an industrial environment, while pollution level 2 is typical for households.

Insulation materials:
Insulation materials are categorized into 4 groups according to the CTI values (Comparative Tracking Index)

Insulation material group I	600≤ CTI
Insulation material group II	400≤ CTI <600
Insulation material group IIIa	175 ≤ CTI <400
Insulation material group IIIb	100 ≤ CTI ≤175

Comparative Tracking Index:
The test for determination of the comparative index of tracking (CTI or comparative tracking index) as per IEC 112 provides a comparison of the characteristics of various insulating materials under test conditions. By dripping an aqueous solution onto a horizontal surface the electrolytic condition can be measured. This produces a qualitative result. When the insulating material is introduced to the tracking, a quantitative comparison can be measured, ex. the comparative tracking index.

Switch contact:
If the construction of the circuit requires that for safety reasons, the circuit power should remain off until one or more contacts are engaged, or that circuit power be turned off prior to one or more contacts being disengaged, then a connector with switch contacts (HBVE Series) should be used.

EMC (electromagnetic compatibility):
The capacity of an electrical installation to function satisfactorily in its electromagnetic environment without an unacceptable influence to the environment which also includes other installations (DIN/VDE 0870, Section 1)

Coding:
Coding is a system by which it is possible to prevent interfacing confusion between adjacent connectors which are of the same configuration. This is useful if two or more connectors of the same type are mounted on the same unit.

Polarization:
Polarization is a method used on connectors which prevents incorrect mating of male and female inserts ex. pin1 to pin1.

PG TO METRIC CONVERSION

As of December 31, 1999 the safety standard VDE 0619 and the therein referenced standards DIN 46319 for metric dimensions and DIN 46320 for PG dimensions were withdrawn.

The new standard DIN EN 50262 became valid as of January 1, 2000.

A 1 to 1 conversion is not possible!

Lapp North America will continue to support PG and Metric components.

PG	M
7	12
9	16
11	20
13.5	
16	25
21	
29	32
36	40
42	50
48	63

Connector Technical Data
IP Ratings

IP mode of protection
IP= “Insulation Protection” is a measure of protection against water and partical ingression that a device can withstand. The level of protection offered by a device is laid down in the manufacturer’s specification according to DIN 40050.

The first digit of the code states the level of protection against partical ingression. The second digit states the level of protection against penetration of water.

Modes of protection as per DIN VDE 0470-1 (EN 60529)

Degrees of protection against solid foreign bodies *First Code:*	**Degrees of protection against water** *Second Code:*
0 No particular protection	0 No particular protection
1 Protection against penetration of solid foreign bodies whose diameter exceeds 50 mm (large foreign bodies) * No protection against intentional access. ex. by hand, but exclusion of larger parts of the body	1 Protection against water dropping perpendicularly. No harmful effect must arise (water drip)
2 Protection against penetration of solid foreign bodies whose diameter exceeds 12 mm. * (medium-sized foreign bodies) to exclude fingers or similar parts	2 Protection against water dropping perpendicularly. No harmful effect must arise with an equipment unit 15° in relation to its normal position (casing) (obliquely water drip)
3. Protection against penetration of solid foreign bodies whose diameter exceeds 2.5 mm (small foreign bodies) * ◊ To exclude tools, wires or similar items whose thickness exceeds 2.5 mm	3 Protection against water dripping at any angle of up 60° to the perpendicular. No harmful effect must arise (water spray)
4. Protection against penetration of solid foreign bodies whose diameter exceeds 1 mm (granular foreign body) * ◊ To exclude tools, wires, or similar items whose thickness exceeds 1 mm	4 Protection against water which splashes onto the equipment unit (ex. casing) from any direction. No harmful effect must arise (water splash)
5. Protection against harmful accumulations of dust. Penetration of dust is not entirely preventive; but must not penetrate in such quantities that the mode of operation of the equipment unit is affected (dust protection) • Complete contact prevention	5 Protection against water steam from a jet which is directed against the equipment unit (casing) from any direction. No harmful effects must arise (water spray)
6. Prevention of penetration of dust (dust proof) Complete contact prevention	6 Protection against heavy sea or powerful water jet. Water must not penetrate the operating equipment in harmful quantities (flooding)
	7 Protection against water if the operating equipment is dipped in water under certain pressure and time. Water must not penetrate in harmful quantities (dipping)
	8 The operating media (casing) is suitable for permanent dipping in water under conditions which are to be defined by the manufacturer (immersion) X

* In the case of operating media of protection levels 1 to 4, consistently or inconsistently formed foreign bodies with three dimensions perpendicular to each other and larger than the corresponding diameter numerical values are prevented from entering.

◊ For degrees of pollution 3 and 4, the application of his table is appropriate for operating media with drain holes or cooling air apertures which are the subject of the responsibility of the corresponding expert commit tee.

• For protection level 5, the application of this table is appropriate for operating media with drain holes, and comes under the responsibility of the respective expert committee.

X This level of protection normally relates to an air-tight field operating medium.
For certain operating media, however, water may penetrate provided that there is no harmful effect.

Connector Technical Data

NEMA Ratings

Nema Type 1: ***General Purpose- Indoor Use:*** Intended to provide protection against contact with the enclosed equipment and against a limited amount of falling dirt.

Nema Type 2: ***Drip Proof-Indoor Use:*** General purpose indoor use intended to be dust proof and provide protection against limited amounts of falling dirt and water.

Nema Type 3: ***Dust tight, Rain Tight and Sleet Resistant- Outdoor Use:*** Intended to provide protection against wind blown dust and rain. Should be undamaged against the formation of ice on the enclosure.

Nema Type 3R: ***Rain Proof and Sleet Resistant-Outdoor Use:*** Intended to provide protection against falling rain. Should be undamaged by the formation of ice on the enclosure.

Nema Type 3S: ***Outdoor Use:*** Intended to provide protection against wind blown dust, rain and sleet. The external mechanisms should remain operable while ice laden.

Nema Type 4: ***Water Tight and Dust Tight- Indoor or outdoor Use:*** Intended to provide protection against dust, falling rain, splashing and hose directed water. Should be undamaged by the formation of ice on the enclosure.

Nema Type 4X: ***Water Tight, Dust Tight & Corrosion Resistant- Indoor or Outdoor Use:*** Intended to provide protection against dust, falling rain and splashing and hose directed water. Should be undamaged by the formation of ice on the enclosure. Should be corrosion resistant.

Nema Type 5: ***Dirt Tight, Dust Tight & Liquid-Tight Indoor Use:*** Intended to provide protection against falling dirt, airborne dust, lint, fibers, and flyings. Also provides protection against dripping and light splashing of liquids.

Nema Type 6: ***Indoor and Outdoor Use:*** Intended to provide protection against the entry of water during temporary and limited submersion. Should remain undamaged by the formation of ice on the enclosure.

Nema Type 6P: ***Indoor and Outdoor Use:*** Intended to provide protection against the entry of water during prolonged submersion at limited depths. Should remain undamaged by the formation of ice on the enclosure.

Nema 7: ***Indoor Use in Hazardous Locations:*** Used in Class 1 Div. 1, Groups A, B, C, or D applications.

Nema 8: ***Indoor or Outdoor Use in Hazardous Applications:*** Used in Class I Div.1, Groups A, B, C, or D applications.

Nema 9: ***Indoor Use in Hazardous Applications:*** Used in Class II, Div.1, Groups E, F, or G applications.

Nema 10: ***Mine Use:*** For meeting requirements of the mine safety and health adminstration, 30 FR, Part 18.

Nema 11: ***Indoor Use:*** Intended to provide corrosion resistance and protection during oil immersion.

Nema 12: ***Indoor Use:*** Intended to provide protection against entry of dust, dirt, and dripping water. Should provide protection against non-corrosive liquids.

Nema 13: ***Indoor Use:*** Intended to provide protection against entry of dust, dirt and dripping water. Should provide protection against non-corrosive liquids.

NEMA RATINGS APPLIED TO EPIC® CONNECTORS

Standard Grey Coating (NEMA 4)

PG

NPT

METRIC

Black Coating (NEMA 4X)

PG

NPT

METRIC

MATERIALS

PA (Polyamides)
Polyamides are high-impact, very tough thermoplastics which exhibit very good electrical insulation characteristics, favorable tracking characteristics and resistance to flashover. The greater the proportion of filling agents, the less the water absorption and the better the dimensional stability. Their specific surface resistance, due to humidity absorption, is somewhat less than for other plastics, but there is the advantage that this reduces the tendency for a build up of electrostatic charge and thus the tendency for PA components to attract dust is avoided.

These characteristics mean that polyamides are suitable for production of casings for electrical plant. (Typical application: high voltage modules, plastic frame grips)

PC (Polycarbonate)
Polycarbonate is an amorphous thermoplastic. It is distinguished by high strength, viscosity, hardness, rigidity and good resistance to heat and cold in relation to its form, and good electrical characteristics. PC is a glass-clear, easily dyed plastic with very low water absorption, and exhibits high dimensional precision, low waste and good processability. (Typical applications: inserts/ insulators, frames and individual modules for modular system)

PBT (Polybutylenterephthalate)
Polybutylenterephthalate is a thermoplastic polyester and is distinguished by its high rigidity, high stability of form under heat, low creep, low water absorption of <0.2%, high dimensional stability and good to very good electrical characteristics. It is a tough viscous plastic with high abrasion resistance, high dimensional stability and long-term strength combined with good slip and wear characteristics. (Typical application: insert/ insulators)

Chemical Resistance of Plastics

Diluted acid	PA 6 GF	PA 66 GF	PC GF	PBT GF
Acetone	+	+	+	+
Aqueous ammoniac	+	+	·	+
Benzene	+	+	+	+
Benzol	+	+	+	+
Diesel oil	+	+	·	+
Concentrated acetic acid	+	+	+	+
Alkaline potassium	·	·	·	°
Methanol	·	·	·	+
Engine Oil	°	°	·	+
Diluted alkalis	+	+	+	+
Chlorhydrocarbons	+	+	·	+
Outdoor exposure	+	+	·	°
Cold water/ seawater	+	+	°	+

+ = resistant; ° = conditionally resistant; · = non-resistant

Electrical, thermal and mechanical values

Electrical Values	Unit	PA 6 GF	PA 66 GF	PC GF	PBT GF
Flash over resistance (DIN 53481; VDE 0303)	Ed * KV/mm	80/40	>80/40	35	100
Tracking current resistance (DIN 53480; VDE 0303)	CTI	>500	>500	>125 to 250	>500
Thermal values					
Temperature limit for short-term application	°C	180	200	165	190
Temperature limit for long-term application	°C	105	120	130	140
Mechanical values					
Density (DIN 53479)	g/ cm3	1.35	1.35	1.34	1.53
Modulus of elasticity in the flexional and tensile test (DIN 53457)	EZ* MPa	8500/ 6000	9700/7500	6000	10000
Absorption of humidity in NK until occurrence of saturation (DIN 5714)	%	2.1	1.5	0.13	0.13

* Numerical information relates to both dry and atmospherically humid conditions

SEALING MATERIALS

NBR (ex. Perbunan)
Synthetic rubber used for parts with high resistance to fuels, oil, fat and aliphatic solvents at high temperatures. The durability of the material can be carried by the compounds used during manufacture, to protect against ozone or the prevailing environmental conditions.

O-Rings are used in various applications ex. electrical and automotive industry, hydraulics, mechanical engineering, oil industry for membranes, fuel hoses, seals, formed items, plate gaskets, etc.

Typical applications: Seals and gaskets for rectangular connectors and glands.

FPM (ex. Viton)
This fluroelastomer is commonly used for rubber parts and withstands fuel, oil, lubricants, many acids and chemicals during extreme thermal stress. Viton also has good mechanical qualities, flame resistance and high durability against ozone and environmental impacts of every kind.

Typical application: Seal in circular connector type A and glands.

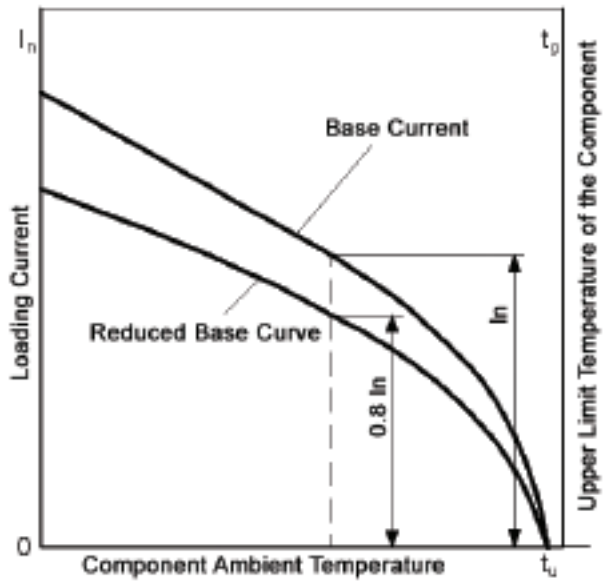
CHEMICAL, THERMAL & MECHANICAL VALUES

Abbreviation	NBR	FPM
Commercial Name	Perbunan N Hycar	Viton/ Fluorel
Shore A hardness range at standard solid quality tolerance ± 5° Shore approx	25 to 40	60 to 90
Tear strength N/ mm2 bei +20°C to	Approx 20	Approx 17
General weather-resistance	good	excellent
Ozone resistance	satisfactory	excellent
Resistance to oil	excellent	excellent
Resistance to fuel	good	excellent
Resistance to solvent	partially good	very good
General resistance to acids	satisfactory	very good
Temperature resistance: a) Short-term: prox b) Long-term: prox	 -40°C to 150°C -30°C to 120°C	 -30°C to 280°C -20°C to 230° C
Vapor resistance	good	satisfactory to good
Can be supplied in food packaging products	yes	no

DERATING CURVES

The derating curve indicates the maximum current that can permanently and simultaneously flow through all connections if the component is exposed to ambient temperatures below its upper limit temperature.

The upper limit temperature of a component is determined by the materials. The maximum temperature is calculated from the ambient temperature and from heating due to current loading, it must not exceed the upper limit temperature of the component. The derating of a component is not a constant value, but decreases hand-in hand with the increase in component ambient temperature. Furthermore, current loading capacity is dependent upon geometry, the materials employed, the number of poles and conductor.



Since it is not advisable to use Heavy Duty connectors at their loading limits, the base curve is reduced. If the loading currents are reduced to 80%, then this produces the reduced base curve in relation to the various connectors and measurement uncertainties at which temperature measurements are taken into account. Experience shows that use of the reduced base curve data will provide operation over the widest range of connector applications.

Note: Only the reduced base curve is reproduced on the following derating curves for inserts.

CABLE OUTER DIAMETERS FOR PG

PG SIZE	CABLE O.D.: MINIMUM TO MAXIMUM	
7	0.157” - 0.236”	4 - 6 mm
9	0.157” - 0.433”	4 - 11 mm
11	0.256” - 0.531”	6.5 - 13.49 mm
13.5	0.256” - 0.531”	6.5 - 13.49 mm
16	0.256” - 0.630”	6.5 - 16 mm
21	0.354” - 0.787”	9 - 20 mm
29	0.669” - 1.102”	17 - 28 mm
36	0.906” - 1.339”	23 - 34 mm
42	1.142” - 1.575”	29 - 40 mm

RECOMMENDED TORQUE FOR EPIC® ASSEMBLY SCREWS

Screw Size	Connector Assembly Part Example	Recommended Torque Metric	Recommended Torque U.S.
M3	HBE, HA Screw Terminals Insert Mounting Screws Guide Pin & Bushing	0.80 Nm	0.59 lb ft (7.08 in lbs)
M4	HD, HDD, HBE, HA Grounding Screw HBS Screw Terminal	1.50 Nm	1.11 lb ft (13.32 in lbs.)
M5	HBS Grounding Screw	2.50 Nm	1.84 lb ft. (22.13 in lbs.)
M6	MP 80A Screw Terminal	3.00 Nm	2.21 lb ft (26.52 in lbs)

* Recommended Torque per Contact GmbH.

Notes:

1. Use the table above to determine torque values that must be used for all screws. All values are metric based, thus torque calculated.
2. Please consult customer service with any additional questions.

CROSS REFERENCE FOR AWG (AMERICAN WIRE GAUGE) TO MM²

AWG	MM²	AWG	MM²
30	0.05	8	10
28	0.08	6	16
26	0.14	4	25
24	0.25	2	35
22	0.34	1	50
21	0.38	2/0	70
21	0.50	3/0	95
20	0.50	4/0	120
19	0.75	300 KCMIL	150
18	1.0	350 KCMIL	185
16	1.5	500 KCMIL	240
14	2.5	600 KCMIL	300
12	4	750 KCMIL	400
10	6	1,000 KCMIL	500

Connector Technical Data

PG Gland Sizes for Multi-Wire Cables

Wire Size: AWG 20: 0.5 mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG
2	5.7 - 8.7	9						
3	6.0 - 9.0	9	11					
4	6.7 - 9.7	9	11	13.5	16			
5	7.2 - 10.2	9	11	13.5	16			
6	7.6 - 10.6	9	11	13.5	16			
7	8.0 - 10.6	9	11	13.5	16			
8	9.4 - 12.8	9	11	13.5	16			
10	9.4 - 12.8	9	11	13.5	16			
12	9.7 - 12.9	9	11	13.5	16			
14	10.2 - 13.4		11	13.5	16			
16	10.7 - 13.9		11	13.5	16			
21	12.3 - 15.1			13.5	16	21		
24	13.5 - 16.7			13.5	16	21		
30	14.3 - 17.5				16	21		
35	16.0 - 18.6					21		
40	16.6 - 19.2					21		
52	19.2 - 21.6					21	29	
61	20.3 - 23.1					21	29	
80	22.9 - 25.7						29	36
100	26.4 - 29.6						29	36

Wire Size: AWG 16 to 18: 1 mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG
2	7.1 - 10.1	9	11					
3	7.5 - 10.1	9	11					
4	8.4 - 10.7	9	11	13.5				
5	9.2 - 11.4	9	11	13.5	16			
6	9.2 - 12.6	9	11	13.5	16			
7	9.2 - 12.6	9	11	13.5	16			
8	11.0 - 14.4		11	13.5	16	21		
9	11.8 - 15.2		11	13.5	16	21		
10	11.0 - 14.4		11	13.5	16	21		
12	11.8 - 14.6		11	13.5	16	21		
14	12.4 - 15.2			13.5	16	21		
16	13.0 - 16.2			13.5	16	21		
18	13.7 - 16.9			13.5	16	21		
20	14.4 - 17.6				16	21		
24	16.5 - 19.1					21		
25	16.9 - 19.5					21		
34	19.4 - 21.8					21		
48	22.0 - 24.8					21		
56	23.2 - 26.0					21	36	
61	24.5 - 27.2						36	
80	27.7 - 30.9						36	
100	31.8 - 35.2						36	42

Wire Size: AWG 12 to 14: 2.5mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG	PG
2	9.8 - 12.8	9	11	13.5	16				
3	10.6 - 13.4		11	13.5	16				
4	11.7 - 14.4		11	13.5	16				
5	13.0 - 16.4			13.5	16	21			
6	13.3 - 16.7			13.5	16	21			
7	13.3 - 16.7			13.5	16	21			
8	17.4 - 20.8					21	29		
11	18.0 - 20.6					21	29		
16	20.6 - 23.4					21	29		
18	21.7 - 24.5						29	36	
25	26.4 - 29.6						29	36	
34	31.3 - 33.1							36	42
50	37.0 - 39.4								42
61	39.0 - 41.5								42

Wire Size: AWG 18: 0.75 mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG
2	6.8 - 9.8	9	11					
3	7.2 - 9.7	9	11	13.5				
4	7.9 - 10.3	9	11	13.5	16			
5	8.9 - 10.9	9	11	13.5	16			
6	8.9 - 12.3	9	11	13.5	16			
7	9.6 - 12.3	9	11	13.5	16			
8	10.4 - 13.8		11	13.5	16			
9	10.7 - 13.9		11	13.5	16			
10	10.4 - 13.8		11	13.5	16			
12	10.7 - 13.9		11	13.5	16			
15	12.3 - 13.5			13.5	16			
18	13.0 - 16.2			13.5	16			
21	13.6 - 16.8			13.5	16	21		
25	15.9 - 18.5				16	21		
32	17.1 - 19.7					21	29	
40	19.0 - 21.4					21	29	
50	21.3 - 24.1					21	29	
61	22.6 - 25.4					21	29	36
80	26.1 - 29.3					21	29	36
100	29.4 - 33.0							36

Wire Size: AWG 16: 1.5mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG	PG
2	8.0 - 11.0	9	11	13.5	16				
3	8.7 - 11.0	9	11	13.5	16				
4	9.7 - 11.8	9	11	13.5	16				
5	10.8 - 13.0		11	13.5	16				
6	10.8 - 14.2		11	13.5	16				
7	10.8 - 14.2		11	13.5	16				
8	13.2 - 16.6			13.5	16	21			
11	13.6 - 16.8			13.5	16	21			
12	17.6 - 16.8			13.5	16	21			
14	14.4 - 17.6				16	21			
16	15.8 - 18.4				16	21			
18	16.6 - 19.2					21	29		
20	17.4 - 20.0					21	29		
25	20.2 - 23.0					21	29		
32	23.8 - 24.5						29	36	
34	22.6 - 25.4						29	36	
42	25.8 - 29.0						29	36	
50	27.0 - 30.2						29	36	
56	27.8 - 31.0						29	36	
61	28.6 - 31.8							36	
80	33.0 - 36.4							36	42
90	34.6 - 37.6							36	42
100	37.8 - 41.4								42

Wire Size: AWG 10 to 12: 4 mm²

# of Wires	Cable Dia. (mm)	PG	PG	PG	PG	PG	PG	PG
2	10.7 - 14.1	9	11	13.5	21			
4	13.0 - 16.4			13.5	21			
5	14.3 - 17.7				21			
7	16.2 - 19.6				21	29	36	
11	Ca.- 24.5						29	36

These tables are based on a representative construction type of multiconductor cable. Other products may vary.

Glossary of Terms

AAR: American Association of Railroads

Abrasion Resistance: Ability of a wire, cable or material to resist surface wear.

Accelerated Aging: Tests where voltage, temperature, etc., are increased above normal operating conditions to obtain observable deterioration in a relatively short period of time. The plotted results give expected service life under normal conditions.

A.C. Resistance: The total resistance offered by a device in an alternating current circuit due to inductive and capacitive effects, as well as the direct current resistance.

Active Current: In an alternating current, a component in phase with the voltage; the working component as distinguished from the idle or watt-less component.

Active Pressure: In an A.C. circuit, the pressure that produces a current as distinguished from the voltage impressed upon the circuit.

Adhesion: The state in which interfacial forces that may be chemical or mechanical in nature hold two surfaces together.

Aging: The irreversible change in properties or appearance of a material with time and under specific conditions (usually accelerated representations of environmental states, such as high temperature, oxygen or other various conditions or media.)

Air Gap: The minimum gap of air between two conducting surfaces permissible at given voltages.

Alloy: A metal formed by combining two or more different metals to obtain different properties.

Alternating Current (AC): Electric current that continually reverses its direction. It is expressed in cycles per second (hertz or Hz).

Ambient Temperature: An all-encompassing temperature within a given area.

Ampacity: The maximum current an insulated wire or cable can safely carry without exceeding either the insulation or jacket material limitations. (Sometimes referred to as Current Carrying Capacity.)

Amp or Ampere: The unit of current. One ampere is the current flowing through one ohm of resistance at one volt potential.

Anneal: The relief of mechanical stress through heat and gradual cooling. Annealing copper renders it less brittle.

Area of conductor: The size of a conductor cross section measured in circular mils, square inches, etc.

Armor: A wrapping of metal, usually steel or aluminum, used for mechanical protection. Placed over the jacket sheath.

Armored Cable: A cable having a metallic covering for protection against mechanical damage.

ASME: The American Society of Mechanical Engineers.

ASTM: The American Society for Testing and Materials.

Attenuation: Power loss in an electrical system. In cables, generally expressed in dB per unit length, usually 1,000 ft.

AWG: Abbreviation for American Wire Gauge. The standard system used for designating wire diameter. The lower the AWG number, the larger the diameter.

AWM: UL or CSA designation for Appliance Wiring Material.

Band Marking: A continuous circumferential band applied to a conductor at regular intervals for identification.

Band Width: The frequency range of transmitted electrical signals, expressed in Hertz.

Bare Conductor: An electrical conductor with no coating or cladding on the copper.

Binder: A spirally served tape or thread used for holding assembled cable components in place awaiting subsequent manufacturing operations.

Bond: The attachment at an interface between an adhesive and an adherent or between materials attached together by adhesive.

Braid: A fibrous or metallic group of filaments interwoven in cylindrical form, covering over one or more wires.

Braid Angle: The smaller of the two angles formed by the shielding strand and the axis of the cable being shielded.

Braid Carrier: A spool or bobbin on a braider which holds one group of strands or filaments consisting of a specific number of ends. The carrier revolves during braiding operations.

Braid Ends: The number of strands used to make up one carrier. The strands are wound side by side on the carrier bobbin and lie parallel in the finished braid.

Glossary of Terms

Breakdown of Insulation: Failure of an insulation resulting in a flow of current through the insulation. It may be caused by the application of too high voltage, defects or decay.

Breakdown Voltage: The voltage at which the insulation between two conductors breaks down.

Breakout: The point at which a conductor or group of conductors break out from a multi-conductor cable to complete circuits at various points along the main cable.

Building Wire: Wire used for light and power, 600 volts or less, usually not exposed to an outdoor environment.

Bunch Stranding: A group of wires of the same diameter twisted together without a predetermined pattern.

Cable: A group of individually insulated conductors in twisted or parallel configuration, with or without an overall covering.

Cable Assembly: A completed cable and its associated hardware ready to install.

Cable Filler: The material used in multiple conductor cables to occupy the spaces formed by the assembly or components, thus forming a core of the desired shape (normally cylindrical).

Cabling: The twisting together of two or more insulated conductors to form a cable.

Cabling Factor: Used in the formula for calculating the diameter of an unshielded, unjacketed cable. D=Kd, where D is the cable diameter, K is the factor and d is the diameter of one insulated conductor.

Capacitance: Storage of electrically separated charges between two plates having different potentials. The value depends largely on the surface area of the plates and the distance between them.

Capacitance, Direct: The capacitance measured directly from conductor to conductor through a single insulating layer.

Capacitance, Mutual: The capacitance between two conductors with all other conductors, including shield, connected to ground.

Cellular Polyethylene: Expanded or "foam" polyethylene consisting of individual closed cells suspended in a polyethylene medium.

Certificate of Compliance (C of C): A certificate which is normally generated by the Quality Control Department, which shows that the product being shipped meets customer's specifications.

Characteristic Impedance: The impedance that, when connected to the output terminals of a transmission line of any length, makes the line appear infinitely long. The ratio of voltage to current at every point along a transmission line on which there are no standing waves.

Circuit: The complete path through which a current flows or part of the complete path, such as one conductor.

Circular Mil: The area of a circle one mil (.001") in diameter; 7.845 x 10-7 sq. in. Used in expressing wire cross sectional area.

Coating: A material applied to the surface of a conductor to prevent environmental deterioration and helps to facilitate soldering.

Coaxial Cable: A cable consisting of two cylindrical conductors with a common axis, separated by a dielectric.

Cold flow: Permanent deformation of the insulation due to mechanical force or pressure (not due to heat softening).

Cold Test: Any test to determine the performance of cables during or after subjection to a specified low temperature for a specified time.

Color Code: A system for circuit identification through use of solid colors and contrasting tracers.

Common Axis Cabling: In multiple cable constructions, a twisting of all conductors about a "common axis" with two conductor groups then selected as pairs. This practice yields smaller diameter constructions than a separate axis construction, but tends to yield greater susceptance to EMI and ESI.

Composite Cable: A cable consisting of two or more different types or sizes of wires.

Compound: An insulating or jacketing material made by mixing two or more ingredients.

Concentric Stranding: A central wire surrounded by one or more layers of helically wound strands in a fixed round geometric arrangement.

Concentricity: In a wire or cable, the measurement of the location of the center of the conductor with respect to the geometric center of the surrounding insulation.

Conductance: The ability of a conductor to carry electric current. It is the reciprocal of resistance and is measured in mhos.

Conductivity: The capability of a material to carry electrical current - usually expressed as a percentage of copper conductivity (copper being 100%).

Conductor: An uninsulated wire or combination of wires suitable for carrying electrical current.

Conduit: A tube or trough in which insulation wire and cables are run.

Glossary of Terms

Connector: A device used to physically and electrically connect two or more conductors. Connectors are a generic device for providing an electrical interface between electrical equipment and/ or a power source. Our connectors may not be mated or unmated under load.

Contact: The part of a connector, which actually carries the electrical current, and are, touched together or separated to control the flow.

Continuity Check: A test to determine whether electricity current flows continuously throughout the length of a single wire or individual wires in a cable.

Control Cable: A multi-conductor cable made for operation in control or signal circuits.

Copolymer: A polymer formed from two or more types of Monomer.

Cord: A small, flexible insulated cable.

Core: In cables, a component or assembly of components over which additional components (shield, sheath, etc.) are applied.

Corona: A discharge due to ionization of air around a conductor due to a potential gradient exceeding a certain critical value.

Corona Test: A test to determine the ability of a cable to withstand the formation of corona under an increasing applied voltage and to extinguish corona when a corona-producing voltage is reduced.

Corrosion: The deterioration of a material by chemical reaction of galvanic action.

Creep distance: The minimum dimension along the surface of an insulating material between two conducting surfaces.

Crimp Termination: A connection in which a metal sleeve is secured to a conductor by mechanically crimping the sleeve with pliers, presses or automated crimping machines.

Cross-Linked: Inter-molecular bonds between long chain thermoplastic polymers by chemical or electron bombardment means. The properties of the resulting thermosetting materials are usually improved.

Crosstalk: Signal interference between nearby conductors by pickup of stray energy. It is also called induced interference.

C.S.A.: Abbreviation for Canadian Standards Association. A not-for-profit membership based association that serves business, industry, government, and consumers in Canda and the global marketplace.

Current: The rate of flow of electricity in a circuit, measured in amperes.

Current-Carrying Capacity: The maximum current an insulated conductor or cable can continuously carry without exceeding its temperature rating. This is also called ampacity.

Cut-Through: Resistance of solid material to penetration by an object under conditions of pressure, temperature, etc.

D.C.: Abbreviation for "Direct Current." DC Values = AC RMS values

Decibel (dB): A unit to express difference of power level. Used to express power gain in amplifiers or power loss in passive circuits of cables.

Derating Factor: A factor used to reduce the current carrying capacity of a wire when used in environments other than that for which the value was established.

Dielectric: Any insulating material between two conductors which permits electrostatic attraction and repulsion to take place across it.

Dielectric Breakdown: The voltage at which a dielectric material is punctured, which is divisible by thickness to given dielectric strength.

Dielectric Constant (K): The ratio of the capacitance of a condenser with dielectric between the electrodes to the capacitance when air is between the electrodes. Also called Permittivity and Specific Inductive Capacity.

Dielectric Strength: The voltage which insulation can withstand before breakdown occurs. Usually expressed as a voltage gradient (such as volts per mil).

Dielectric Test: A test in which a voltage higher than the rated voltage is applied for a specified time to determine the adequacy of the insulation under normal conditions.

Direct Burial Cable: A cable installed directly into the earth.

Direct Capacitance: The capacitance measured directly from conductor to conductor through a single insulating layer.

Direct Current (DC): An electric current, which flows in only one direction.

Direct Current Resistance (D.C.R.): The resistance offered by any circuit to the flow of direct current.

Drain Wire: In a cable, the uninsulated wire in contact with a shield to provide for easier termination of such a shield to a group point.

Electromagnetic: Pertaining to the combined electric and magnetic fields associated with movements of electrons through conductors.

Glossary of Terms

Electrostatic: Pertaining to static electricity or electricity at rest. A constant intense electric charge.

Elongation: The fractional increase in length of a material stressed in tension.

EMI: Abbreviation for Electromagnetic Interference.

Ends: In braiding, the number of essentially parallel wires or threads on a carrier.

Ethylene Propylene Rubber (EPR): An ozone resistant rubber consisting primarily of ethylene propylene copolymer (EPM) or ethylene propylene diene monomer (EDPM).

Extrusion: The process of continuously forcing both a plastic or elastomer and a conductor core through a die, thereby applying a continuous coating of insulation or jacket to the conductor or core.

Farad: A unit of electrical capacity.

FEP: Fluorinated Ethylene Propylene is a "Teflon" fluorocarbon resin and is a registered TM of the DuPont Company. This is a melt extrudable fluorocarbon resin.

Filler: A material used in multi-conductor cables to occupy large interstices formed by the assembled conductors. 2) An inert substance added to a compound to improve properties or decrease cost.

Flame Resistance: The ability of a material to extinguish flame once the heat source is removed.

Flame Retardance: Ability of a material to prevent the spread of combustion by a low rate of travel so the flame will not be conveyed.

Flammability: The measure of the material's ability to support combustion.

Flammability Test: A test to determine the ability of a cable to resist ignition when placed near a source of heat or flame and to self-extinguish when removed from the heat source.

Flat Cable: A cable with two smooth or corrugated but essentially flat surfaces.

Flex Life: The measurement of the ability of a conductor or cable to withstand repeated bending.

Flexible: The quality of a cable or cable component which allows for bending under the influence of an outside force, as opposed to limpness which is bending due to the cable's own weight.

Flexibility: The ease with which a cable may be bent.

Frequency: Number of times that an alternating current reverses itself in one second. Expressed in Hertz (Hz), which is one cycle per second.

Ground: A conducting connection between an electrical circuit and the earth or other large conducting body to serve as an earth thus completing the electrical circuit.

Halogen: Any of the five elements: Fluorine, chlorine, bromine, iodine and astatine. These elements may be combined with insulation compounds to enhance flame retardancy.

Harness: An arrangement of wires and cables, usually with many breakouts, which have been tied together or pulled into a rubber or plastic sheath, used to interconnect an electric circuit.

Heat Resistance: Ability of a substance to maintain physical and chemical identity and electrical integrity under specified temperature conditions.

Heat Shock: A test to determine stability of a material by sudden exposure to a high temperature for a short period of time.

Helical Stripe: A continuous, colored, spiral stripe applied to a conductor for circuit identification.

Henry: Unit of inductance such that the induced voltage in volts is numerically equal to the rate of change in current in amperes per second.

Hertz (Hz): A term replacing cycles-per-second as a unit of frequency.

Hi-Pot: A test designed to determine the electrical integrity of an insulation.

Hook-up Wire: A single insulated conductor used for low-current, low voltage (usually under 600 volts) applications within enclosed electronic equipment.

Hypalon: DuPont's trade name for their chlorosulfonated polyethylene, an ozone resistant synthetic rubber.

Hz: Abbreviation for Hertz.

Impact Strength: A test for determining the mechanical punishment a cable can withstand without physical or electrical breakdown by impacting with a given weight dropped a given distance, in a controlled environment.

Glossary of Terms

IEC: European Standardization agency; International Electrotechnical Commission.

Impedance: The total opposition that a circuit offers to the flow of alternating current or any other varying current at a particular frequency. It is a combination of resistance and resis and is measured in ohms.

Inductance: The property of a circuit or circuit element that opposes a change in current flow, thus causing current changes to lag behind voltage changes. It is measured in Henrys.

Insulation: A material having high resistance to the flow of electric current. Often called dielectric in radio frequency cable which is used to separate close electrical components, such as cable conductors and circuit components.

Insulation Resistance (I.R.): The resistance offered by insulation to an impressed DC voltage, tending to produce a leakage current through the insulation.

Insulation Thickness: The wall thickness of the applied insulation.

Interference: Any undesired electrical signal induced into a conductor by electrical or electromagnetic means.

Interstices: Voids or valleys between individual strands in a conductor or between insulated conductors in a multi-conductor cable.

Irradiation: In insulations, the exposure of the material to high-energy emissions for the purpose of favorably altering the molecular structure by cross-linking.

Jacket: An outer covering, usually nonmetallic, mainly used to protect the cable core from the environment.

KCMIL: Conductor area expressed in thousands of circular mils.

Lay: The axial distance required for one cabled conductor or conductor strand to complete one revolution about the axis around which it is cabled.

Lay Direction: The twist in the cable as indicated by the top strands while looking along the axis of the cable away from the observer. Described as "right hand" or "left hand".

Line Voltage: The value of the potential existing on a supply or power line.

Load: A device that consumes power from a source and uses that power to perform a function.

Longitudinal Shield: A tape shield, flat or corrugated, applied longitudinally with the axis of the core being shielded.

Lower limit temperature: The lower limit temperature is the minimum permissible temperature at which a Heavy Duty connector can still be operated.

Magnetic Field: The region within which a body or current experiences magnetic forces.

Magnetic Noise: Caused by change in current level, e.g., AC power line (created magnetic field around the cable) this magnetic field causes the magnetic noise.

Mating cycles: Mating cycles are the number of insertion and extraction cycles a connector can withstand before electrical or mechanical failure in relationship to the connector's design specification.

Megohm: One million ohms.

Member: A group of insulated wires to be cabled with other stranded groups into multiple-element cable.

Messenger: The linear supporting member, usually a high strength steel wire, used as the supporting element of a suspended aerial cable. The messenger may be an integral part of the cable, or exterior to it.

Mil: A unit used in measuring diameter of a wire or thickness of insulation over a conductor. One one thousandth of an inch (.001").

Moisture Absorption: The amount of moisture, in percentage, that a material will absorb under specified conditions.

Moisture Resistance: The ability of a material to resist absorbing moisture from the air or when immersed in water.

Multiconductor: More than one conductor within a single cable construction.

Mylar®: DuPont trademark for polyester tape material.

National Electrical Code (NEC): A consensus standard published by the National Fire Protection Association (NFPA 70) and incorporated in OHSA regulations. These regulations govern construction and installation of electrical wiring and apparatus in the U.S.

NEMA: National Electrical Manufacturers Association.

Neoprene: Trade name for polychloroprene synthetic rubber, a compound used for jacketing.

Nylon: A group of polymers that are used for the jacketing of wire and cable.

Glossary of Terms

Ohm: The electrical unit of resistance. The value of resistance through which a potential difference of one volt will maintain a current of one ampere.

Ohm's Law: E = I X R. Voltage (E) is directly proportional to the product of current (I) and resistance (R) of circuit.

OSHA: Abbreviation for Occupation Safety and Health Act. Specifically the Williams-Steiger law passed in 1970 covering all factors relating to safety in places of employment.

Overall Diameter: Finished diameter over wire or cable.

Overlap: The amount the trailing edge laps over the leading edge of a tape wrap.

Oxygen Index: Percentage of oxygen necessary to support combustion of a material.

Pair: Two insulated wires of a single circuit associated together.

PAP: A commonly used term for air core (unfilled) direct burial telephone cable with a corrugated aluminum shield.

Parallel Cable: Two insulated conductors that run parallel in a cable.

PCB Solder Contacts: Circular contacts which mount directly to a circuit board.

PE: Physical Earth, the same as ground.

Peak Voltage: Maximum instantaneous voltage.

Pick: Distance between two adjacent crossover points of braid filaments. The measurement in picks per inch indicates the degree of coverage.

Pitch: In flat cable, the nominal distance between the index edges of two adjacent conductors.

Pitch Diameter: Diameter of a circle passing through the center of the conductors in any layer of a multi-conductor cable.

Plastic Deformation: Change in dimensions under load that is not recovered when the load is removed.

Plasticizer: A chemical agent added to plastics to make them softer and more pliable.

Plenum: The air return path of a central air handling system, either ductwork or open space over a dropped ceiling or beneath a floor.

Plenum Cable: Fire and smoke resistant cable Listed by Underwriters Laboratories for installation in plenums without the need for conduit.

Polyester: Polyethylene terephthalate that is used extensively in the production of a high strength moisture resistant tape or film used as a cable core wrap.

Polyethylene: A thermoplastic material having the chemical identity of polymerized ethylene.

Polymer: A substance made of many repeating chemical units or molecules. The term polymer is often used in place of plastic, rubber, or elastomer.

Polyolefin: A family of thermoplastics based upon the unsaturated hydrocarbons known as olefins. When combined with butylene or styrene polymers they form compounds such as polyethylene and polypropylene.

Polypropylene: A thermoplastic polymer of propylene.

Polyvinyl Chloride (PVC): A thermoplastic material composed of polymers of vinyl chloride that may be rigid or flexible, depending on specific formulation.

Porosity: Multiple air voids in an insulation or jacket wall.

Rated Current: The rated current is the current at which a connector can continuously (not intermittently) conduct through all contacts simultaneously without exceeding the upper limit temperature.

Rated Temperature: The maximum temperature at which an electric component can operate for extended periods without loss of its basic properties.

Rated Voltage: The maximum voltage at which an electric component can operate for extended periods without undue degradation or safety hazard.

Reinforcement: A material used to strengthen or give dimensional stability to another material.

Resin: An organic substance of natural or synthetic origin characterized by being polymeric in structure and predominantly amorphous. Most resins, though not all, are of high molecular weight and consist of a long chain or network molecular structure.

Resistance: In DC circuits, the opposition a material offers to current, measured in ohms. In AC circuits, resistance is the real component of impedance, and may be higher than the value measured at DC.

Retractile Cable: A cable that returns by its own stored energy from an extended condition to its original contracted form.

Glossary of Terms

RG/U: Abbreviation for Radio Government, Universal. RG is the military designation for coaxial cable and U stands for "general utility."

Ribbon Cable: A flat cable of individually insulated conductors lying parallel and held together by means of adhesive or woven textile yarn.

Ringing Out: The process of locating or identifying specific conductive paths by means of passing current through selected conductors.

Rise Time: The time required for the initially zero potential existing on transmission line (which is terminated in its characteristic impedance) to change from 10% to 90% of its full DC value after a DC potential source is instantaneously applied.

Routing: The path followed by a cable or conductor.

Rupture: In the breaking strength or tensile strength tests, the point at which the material physically separates or comes apart, as opposed to elongation, yield strength, etc.

SAE: Abbreviation for Society of Automotive Engineers.

Self-Extinguishing: The characteristic of a material whose flame extinguishes after the igniting flame is removed.

Self-Supporting Cable: Any cable that incorporates a steel rope or steel sheath for added tensile strength, thus enabling it to be suspended between widely spaced supports.

Semi-Rigid PVC: A hard, semi-flexible polyvinylchloride compound with low plasticizer content.

Separator: A layer of insulating material such as textile, paper, polyester, etc. Used to improve stripping qualities, flexibility, mechanical or electrical protection of the components.

Serve: A filament or group of filaments such as fibers or wires, wound around a central core.

Served Wired Armor: Spiral wrap of soft galvanized steel wires wrapped around a cable to afford mechanical protection and increase the cable pulling tension characteristics.

Sheath: The outer covering or jacket of a cable.

Shield: A metallic layer placed around a conductor or group of conductors to prevent electrostatic interference between the enclosed wire and external fields.

Shield Coverage: The physical area of a cable that is actually covered by the shielding material and is expressed as a percent.

Shock Test: A test to determine the ability of a cable to withstand a violent physical concussion such as one that might occur during handling or use.

Signal: A current used to convey information, either in digital, analog, audio or video.

Solid Conductor: A conductor consisting of a single wire.

Specific Gravity: The ratio of the density (mass per unit volume) of a material to that of water.

Stranded Conductor: A conductor composed of groups of wires twisted together.

Strip Force: The force required to remove a small section of insulating material from the conductor it covers.

Suggested Working Voltage: AC voltage that can be applied between adjacent conductors.

Teflon®: A registered trademark of Dupont and is used in relation to products manufactured with Dupont's fluoropolymer products.

Temperature Rating: The maximum temperature at which an insulating material may be used in continuous operation without loss of its basic properties.

Tensile Strength: The pull stress required to break a given specimen.

Test Voltage: The maximum voltage at which a connector will not be subjected to flashover under the set conditions.

Thermal Rating: The maximum and/or minimum temperature at which a material will perform its function without undue degradation.

Thermocouple: A device consisting of two dissimilar metals in physical contact, which when heated will develop an emf output.

Thermoplastic: A material that will soften, flow or distort appreciably when subjected to heat and pressure.

Thermoset: A material which hardens or sets by heat, chemical or radiation cross-linking techniques and which, once set, cannot be resoftened by heating.

Tray: A unit or assembly of units or sections, and associated fittings, made of noncombustible materials forming a rigid structural system used to support cables.

Glossary of Terms

Tray Cable: A factory-assembled multiconductor or multipair control, signal or power cable specifically approved under the National Electrical Code for installation in trays.

Twisted Pair: Two small separately insulated wires twisted together without a common covering.

UF: Thermoplastic Underground feeder and branch circuit cable.

UGF: Abbreviation for ultra high frequency, 300 to 3000 MHz.

UL: Abbreviation for Underwriters Laboratories, an independent, not for profit product safety testing and certification organization.

Unilay: More than one layer of helically laid wires with the direction of lay and length of lay the same for all layers.

Upper limit temperature: The upper limit temperature is the maximum permissible temperature, at which a Heavy Duty connector can still be operated, due to the heating up of the contacts by the ambient temperature or other environmental conditions.

Valley: Any void between the insulated conductors of a cable or between a cable core and its covering. See also interstice.

Velocity of Propagation: The speed of an electrical signal down a length of cable compared to speed in free space expressed as a percent. It is the reciprocal of the square root of the dielectric constant of the cable insulation.

Video Pair Cable: A transmission cable containing low-loss pairs with an impedance of 125 ohms. Used for TV pick-ups, closed circuit TV, telephone carrier circuits, etc.

Volt: A unit of electrical pressure. One volt is the amount of pressure that will cause one ampere of current in one ohm of resistance.

Voltage: Electrical potential or electromotive force expressed in volts.

Voltage Rating: The highest voltage that may be continuously applied to a wire in conformance with standards or specifications.

Vulcanization: An irreversible process during which a rubber or polymeric compound through a change in its chemical structure (for example, cross-linking) becomes a thermoset.

Wall Thickness: The thickness of the applied insulation or jacket.

Water Absorption: Water by percent weight absorbed by a material after a given immersion period.

Watt: A unit of electrical power. One watt is equivalent to the power represented by one ampere of current under a pressure of one volt in DC circuit.

Wavelength: The distance, measured in the direction of propagation, of a repetitive electrical pulse or waveform between two successive points.

Wicking: The longitudinal flow of liquid in a wire or cable due to capillary action.

XLPE: Abbreviation for cross-linked polyethylene.

CONVERSION FACTORS

Length	Volume	Mass	Area
Inch x 25.40 = Millimeters Millimeters x 0.03937 = Inches Feet x 0.3048 = Meters Meters x 3.281 = Feet Miles x 1.609 = Kilometers Kilometers x 0.6214 = Miles ohms/km x 0.3048 = ohms/mft	Cu. Inch x 16.39 = Cu. Centimeter Cu. Cm. x 0.06102 = Cu. Inch Cu. Foot x 0.02832 = Cu. Meter Cu. Meter x 35.31 = Cu. Foot	Ounce x 28.35 = Gram Gram x 0.03527 = Ounce Pound x 0.4536 = Kilogram Kilogram x 2.205 = Pounds Kilogram/km x 0.67198 = Pounds/mft Pounds/mft x 1.4881 = Kilogram/km	Sq. Inch x 6.452 = Sq. Centimeter Sq. Centimeter x 0.1550 = Sq. Inch Sq. Foot x 0.0929 = Sq. Meter Sq. Meter x 10.76 = Sq. Foot Sq. Mile x 2.590 = Sq. Kilometer Sq. Kilometer x 0.3861 = Sq. Mile Circular Mil x 0.7854 = Sq. Mil mm^2 = (Strand mm)^2 x (# Strands) x (.7854)

CROSS REFERENCE FOR AWG (AMERICAN WIRE GAUGE) TO MM^2

AWG	MM^2	AWG	MM^2
30	0.05	8	10
28	0.08	6	16
26	0.14	4	25
24	0.25	2	35
22	0.34	1	50
21	0.38	2/0	70
21	0.50	3/0	95
20	0.50	4/0	120
19	0.75	300 KCMIL	150
18	1.0	350 KCMIL	185
16	1.5	500 KCMIL	240
14	2.5	600 KCMIL	300
12	4	750 KCMIL	400
10	6	1,000 KCMIL	500