

A LEVITON
COMPANY

AMERICAN[®]
INSULATED WIRE CORP.

A Guide to Wire and Cable Construction

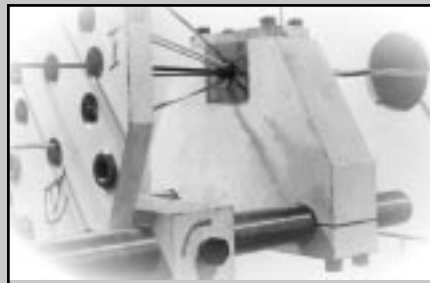


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INTRODUCTION

Welcome to American Insulated Wire Corporation’s “Guide to Wire & Cable Construction.” It is designed to help you gain a more complete understanding of the basics of wire and cable, and if you are already at that point, it will enhance your existing knowledge. Whatever the case may be, this will be a valuable source of information for you, and it will allow you to more efficiently service the needs of those that you work with.

This manual focuses on many aspects of wire and cable, such as basic electricity, manufacturing processes, selection and types of materials and compounds, and different governing agencies. (American offers a separate booklet focusing on its full line of products.)

There are a variety of end-user requirements or applications so our wires and cables are available in a broad range of standard types and optional constructions.

Variable characteristics include:

- Size (AWG or KCMIL)
- Strength (Physical)
- Cold Temp. Withstand
- Radiation Resistance
- Weight
- Electrical Properties
- Chemical/Oil Resistance
- Moisture Resistance
- Flexibility
- Heat/Operating Temp.
- Mechanical Damage
- Sunlight & Flame Resistance

Availability and reasonable costs are also important considerations.

The information found in this guide will help you focus on the appropriate selection of materials to sell, recommend and manufacture wire and cable products that meet application needs.

Quality Policy:

“American Insulated Wire Corp. is committed to a quality system of continuous improvement for use in the manufacturing of wire and cable products. It is our policy to develop, produce and deliver products and services which consistently meet our customers’ needs.”

Mission Statement:

“To provide unparalleled service while manufacturing the highest quality product to meet our customers needs at a competitive price.”



CORPORATE PROFILE

American Insulated Wire is a leading manufacturer and supplier of electrical and electronic wire, including power cable, building wire, control cable, portable cable and flexible cord, power supply and cord set products, serving a variety of markets through electrical distributors and direct to OEMs. American’s breadth of products allows it to be classified as a total source supplier of custom and standard wire and cable products to meet diverse industrial requirements.

American was founded in 1924 and became a subsidiary of Leviton Manufacturing Company (Little Neck, NY), an internationally known manufacturer of wiring devices, in 1937. The company has three manufacturing sites, located in South Attleboro, Massachusetts, Pawtucket, Rhode Island, and Coffeyville, Kansas.

American is backed by technical service, quality assurance, engineering and manufacturing, R&D and testing facilities that have earned a reputation for quality, precision and reliability.

Our Business Development Representatives are responsible for specification development with engineering architects and industrial MRO/OEM communities for all American products. Their primary goal is develop end-user specifications for the company’s range of products.

Markets American Serves

American Insulated Wire’s products are used to help provide electricity for: 1) appliances (i.e. coffee makers

and lamps); 2) electrical tools; and, 3) industrial, commercial and residential buildings. American plays a vital role in supplying the world with electrical and electronic wire, cable and cord products. Our products can be found in the home, steel mills, at construction sites, telephone companies, malls, sport complexes – almost anywhere there’s a need for electricity. To meet customer needs, we serve three markets - *Electrical Distribution, OEM, and Telecommunication.*

Electrical Distribution

American Insulated Wire goes to market by serving the electrical distributor who, in turn, resells the product to the end-user. To assist this customer base, American employs an aggressive sales organization which includes specification specialists whose purpose is to help end-users in specifying the correct products for their applications. American’s sale force works with electrical distributors by providing various types of product information including new product updates, training, end-user calls, inventory and pricing.

OEM Market

American is a leader in the manufacture of wire, cable and cord products for the OEM marketplace. The company produces a complete line of hook-up wire, portable cable, flexible cords and and power supply cords to meet OEM specifications or requirements. Because American utilizes an OEM sales force that is technically oriented and

provides engineering support, the company offers assistance to customers during the development stage of the OEM product. In many instances, American assisted a customer in the design of a product that has helped reduce the manufactured cost of the final product. American has also worked with OEMs to design wire, cable and cord products that provide value added features.

Telecommunications Market

American is the recognized leader in providing the Telecommunication Industry central office power cable products, as well as products for inside and outside plant use. The company has continued to be in the forefront in the development of products to meet the needs and requirements of the telecommunications industry. This includes non-halogenated and low smoke designed power cable products and is currently working on the next generation. We manufacture standard types of wire and cable products for the telecommunications industry and custom or engineered product to customer specifications or requirements.

STANDARD

A standard is "An agreement on a definition." By referencing standards which may be either a test method, or a physical or electrical description, the task of obtaining a cable having the desired properties is simplified.

Standard Making Bodies

ICEA	Insulated Cable Engineers Association
NEMA	National Electrical Manufacturers Association
AEIC	Association of Edison Illuminating Companies
UL	Underwriters Laboratories Incorporated
c(UL)	Underwriters Laboratories Incorporated (Canada)
CSA	Canadian Standards Association
CSA NRTL	Canadian Standard Association
CSA NRTL/C	Canadian Standard Association
NEC	National Electrical Code
ANSI	American National Standards Institute
AAR	American Association of Railroads
IMSA	International Municipal Signal Association
ASTM	American Society for Testing and Materials
AAA	Aluminum Association of America
ISA	Instrument Society of America
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission

BASIC ELECTRICITY

Transmitting electricity is the basic function to be considered when making wire and cable perform properly. Metal

conductors carry the electrons which is generated by an electromotive force.. There are three major components of basic electricity:

1. *Volts*—The force of the electricity being generated. Insulation thickness is determined by the specified voltage.
2. *Amps*—The actual quantity of the electricity being generated. Conductor size is determined by the required ampacity.
3. *Watts*—The total measurement of the electricity being generated, i.e., power.

$$WATTS = VOLTS \times AMPS (W = V \times A)$$

SPECIFICATION

A specific listing of requirements which may be complete in itself or refer in part or in total to various standards (including gauge size, conductor, insulation and jacketing materials, etc.).

CONDUCTOR MATERIALS

Copper

The principal electrical conductor due to its excellent conductivity and reasonable cost.

Aluminum

61% the conductivity and .3027 times the weight of copper. Used in power cables, overhead (ACSR), and some building wire.

Copperweld

A thin coating of copper fused to a steel core. Used in line wire, cable messengers and stranded with copper for strength or extending flex life.

Alumoweld

A thin coating of aluminum fused to a steel core. Used in line wire and cable messengers.

Tinsel

Flat ribbons of bronze, silver, or copper alloy spiraled around a textile core of cotton, nylon, etc. Used in telephone and electronics applications as conductors in line cords, microphone cords, and retractile cords.

Thermocouple

Special matched Alloy Conductors. Used in temperature measuring applications.

Copper Materials for Electrical Conductors

ETP	Electrolytic Tough Pitch) ASTM B-5
F RTP	Fire Refined Tough Pitch) ASTM B-4 (Lake Copper)

CONDUCTOR TERMINOLOGY

Gauge

A system for specifying wire size. The American Wire Gauge (AWG), also known as Brown & Sharpe Gauge, is used for copper. An increase of three gauge numbers: *Doubles Area & Weight, Halves D.C. Resistance.*

MCM - An older term used to denote 1,000 circular mils.

KCMIL - Newer term used to denote 1,000 circular mils.

CM (Circular Mil)

A system for specifying wire size by conductor area. Circular mils are obtained by multiplying the individual wire diameter in inches by 1,000, squaring the result, and multiplying by the number of wires.

IACS (International Annealed Copper Standard)

A standard of copper conductivity obtained by specifying resistivity and temperature.

Wire Coatings

Applied over conductors to prevent some insulations from attacking or adhering to copper. Eliminates difficulties in soldering and prevents deterioration of copper at *high temperatures.*

Coating	Max. Cond. Rating
Tin	200°C
Lead Alloy	90°C
Nickel	250°C
Silver	250°C

Note: Lead alloy is being phased out.

TINNING DESIGNATIONS

Bare Copper

Uncoated copper.

Tin Copper

Copper coated with tin by running through a pot of commercially pure tin, then through wiping dies. (2 mg./sq. in. free tin min.) Tinning prevents insulation from attacking copper, eliminates difficulties in soldering and prevents deterioration of copper at high temperatures.

Heavy Tin

By running through a pot of commercially pure tin then through wiping dies. (4mg./sq. in. free tin min.) The purpose of this is to furnish a conductor which will bond under induction heat after insulation. The tin on the individual strands flows, under heat, resulting in a solid mass at the point desired, leaving the rest of the conductor unbonded with its normal flexibility. The additional tin also enhances the soldering operation.

Bare Copper Overtinned

Uncoated stranded conductor run through a tin pot, with the excess tin being blown away by air. This results in light bonding for higher flex life but lower bond strength.

Bare Copper Fused

Uncoated stranded conductor run through a tin pot and special wiping dies, which direct the tin into and almost completely fills the interstices of the conductor for heavy bonding, which results in higher bond strength with some sacrifice in flex life.

Tin Copper Overtinned

Same as Bare Copper Overtinned except the individual strands are tinned before stranding.

Tin Copper Fused

Same as Bare Copper Fused except the individual strands are tinned before stranding.

Prebond

Heavy tin coated individual wires stranded then bonded by resistance heat. (Similar to Heavy Tin except the entire conductor is bonded before other operations, such as insulating, are started.) *Note* - some insulated wire manufacturers also use the term "Prebond" to mean any stranded wire which has been fused or overtinned.

Topcoat

Equal to Bare Copper Overtinned.

Overcoat

Equal to Tin Copper Fused.

ANNEALING

A process in which the conductor is heated to over 700°F and allowed to cool. Used to allow conductors to be bent without breaking, remove stiffness and improve flexibility.

CONDUCTOR MAKING PROCESS

Wire Bars

An approximately 200 pound billet of copper. Roughly 54" long x 3-7/8" wide x 3-5/8" high. Used as the feedstock for making rod.

Rod

A 5/16" or 3/8" diameter rod of copper drawn from wire bars drawn down to make solid conductors and individual strands.

Stranding

The twisting together of small wires to form a single larger conductor. Used to provide flexibility, ease of handling and vibration resistance.

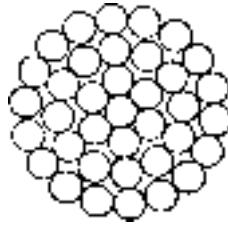
Bunch Strand (ASTM B-174)

A conductor formed by the simple twisting together in one direction of many small wires. Generally used in flexible cords, constant flexing control cables and extra-flexible lead wires.

Concentric Strand (ASTM B 8)

A conductor formed in a layer pattern generally with 7, 19, 37, 61 or 91 wires. Normally, adjacent layers have a reversed direction of lay.

Control cables favor 7 or 19 wires and power cables 7 through 91 wires depending on size or flexibility desired.



Rope Lay—Bunch Stranded Members (ASTM B-172)

A conductor formed by assembling 7 or 19 bunch stranded conductors to form a simple rope. In larger sizes 7, 19, or 37 simple ropes may be assembled to form the complete rope.

Examples using three strand designations are:

AWG/MCM	Class I	Class K	Class M
#6	7x9/.0201"	7x38/.010"	19x35/.0063"
250MCM	7x7x13/.0201"	7x7x51/.010"	19x7x48/.0063"

Used for flexible power cables, portable power cables and welding cables where great flexibility is desired.

Rope Lay—Concentric Stranded Members (ASTM B-173)

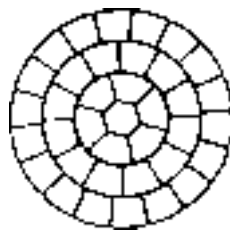
A conductor formed by assembling 7 or 19 concentric stranded conductors to form the completed conductor. Examples using two strand designations are:

AWG	Class G	Class H
#14	7x7/.0092"	Not Recognized
#4	7x7/.0292"	19x7/.0177"

Used in cables where some flexing is to be encountered, and ease in bending or training is required.

Compact Round Conductor (ASTM B-496)

A concentric stranded conductor with the layers of individual wires all laid in the same direction and rolled or die compacted by layer to a predetermined size. This results in an extremely smooth conductor surface, approximately that of a solid conductor at the same time preserving most of the flexibility of a stranded conductor. Advantages are minimum overall diameter for a given conductor area and freedom from "bird caging" of strand under bending, and the practical elimination of nearly all space between strands. Used in some high voltage power cables.

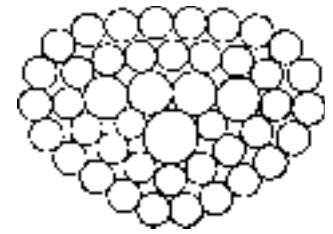


Compressed Round Conductor (ASTM B-8)

A concentric lay conductor which has been run through a die and is reduced 3% in diameter in comparison to its ASTM specified non-sized structure. Used in most concentric stranded conductors.

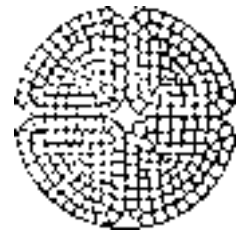
Sector Conductor

A sector conductor is a stranded conductor whose cross section is approximately the shape of a sector of a circle. A multi-conductor insulated cable with sector conductors has a smaller diameter than the corresponding cable with round conductors. Rarely used.



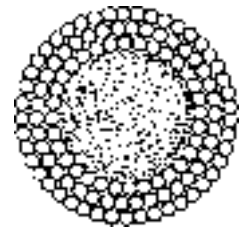
Segmental Conductor

A segmental conductor is a round, stranded conductor composed of three or four sectors slightly insulated from one another. This construction has the advantage of lower a-c resistance (less skin effect). Now rarely used.



Annular Conductor

An annular conductor is a round, stranded conductor whose strands are laid around a suitable core. The core is usually made wholly or mostly of non-conducting material. This construction has the advantage of lower total a-c resistance for a given cross-sectional area of conducting material by eliminating the greater skin effect at the center. Now rarely used.



Filled Strand

A substance is applied by wiping all interstices of the strand which serves to block the flow of liquids or gases through and along the strand. Used in some pump cables, shipboard cables, cables in hazardous locations, and direct burial power cables.

WIRE DRAWING

(Machinery types are Waterbury, Synchro, etc.)

Rod Breakdown Machines

Takes 5/16" rod and reduces size to:
Soft—(annealed) #14-#6 AWG solid.
Hard—#14-#8 AWG for redrawing on Intermediate machines

Intermediate Machines

Redraws to smaller AWG strand sizes:
Examples #8 to #18; #10 to #22
 #12 to #24 or .0147 & .0185" strand

Fine Wire Machines

Redraws #18 or #20 AWG to Fine Strand #30, #34 or #36 AWG.

Dies

A series of progressively smaller dies are used to reduce wire diameter to the desired size.

Carbide Dies—Used down to #14 AWG

Diamond Dies—Used on #14 AWG and smaller

Drawing Solution

A liquid soluble fat solution which is pumped over dies and copper to cool die and prevent fusion of die and copper.

WIRE ASSEMBLY MACHINES**Bunchers (Twisters)**

Used to make bunch strand conductors:

Types: *Watson V-7 & V-10, Haskell-Dawes, Bartell, Laribee, Cook B-16 & B-24 & B-22.*

Tubular or Barrel Stranders (Concentric)

Used to make 7 & 19 Wire Concentric Conductors:

Types: *Watson, Bartell, Wire Machinery of America.*

Strander (Concentric)

Used to make large size concentric conductors:

Types: *Watson*

ASTM STANDARDS FOR COPPER CONDUCTORS

B-3	Soft or annealed copper wire
B-8	Concentric-lay stranded copper conductors
B-33	Tinned soft or annealed copper wire for electrical purposes
B-172	Rope-lay-stranded copper conductors having bunch-stranded members for electric conductors
B-173	Rope-lay-stranded copper conductors having concentric stranded members for electrical conductors.
B-174	Bunch-stranded copper conductors for electrical conductors.
B-189	Lead coated and Lead alloy coated soft copper wire for electrical purposes
B-286	Copper conductors for use in hook-up wire for electronic equipment.
B-496	Compact round concentric lay-stranded copper conductors.

Lay (one helical path)

The distance between successive points where the same strand (or insulated conductor) when twisted with one or more strands (or insulated conductors) presents itself in the same position.

Direction of Lay

The direction of lay of strand (or insulated wire) is determined by the position and direction of the top strand (or insulated wire) when looking away from the viewer along the axis of the conductor (or cable). *Example:* A right hand lay is indicated when the top strand (or insulated wire) goes away from and to the right of the viewer (clockwise) looking along the axis of the conductor (or cable).

Bird Caging

A condition in which the inner layer comes through the outer layer, backing up and bulging out. This condition sometimes occurs in concentric stranded conductors (or cables) when the lay is too long or assembly tensions are incorrect.

INSULATION AND JACKETS**User needs that determine the material selection for Insulations & Jackets**

- Size (Wall Thickness)
- Electrical (Capacitance, Insulation resistance, dielectric strength, etc.)
- Physical (Cut-through, abrasion resistance, deformation, etc.)
- Chemical resistance
- Environmental conditions
- Service Life
- Reliability
- Flexibility
- Radiation resistance
- Smoke generation
- Flame resistance

Insulation

Applied over conductors for electrical isolation between conductors or from ground.

Jacket

Applied over conductor insulation or cable core for mechanical, chemical, or electrical protection.

Classes**Thermosetting (rubbers such as neoprene, hypalon, etc.)**

A term used to describe materials which are processed using steam, dry heat or radiation. After processing the materials can not be made to flow under the application of heat. Radiation, dry heat and steam processing (C.V. Tube) use complex equipment. Production is slow.

Thermoplastic (PVC, Polyethylene, TPE, Nylon etc.)

A term used to describe materials which are processed by an extruder. After processing the materials can be repeatedly made to flow under the application of heat. Processing on an extruder requires relatively simple equipment. Production is fast.

Special Definitions**Fluoropolymer (Teflon FEP, etc.)**

Insulations or jackets characterized by the presence of fluorine in the formulation.

Elastomer

A material that has the ability to recover from extreme deformation. (In the order of hundreds of percent.) It may be thermosetting or thermoplastic.

Rubber (By ASTM Definition)

A material which is capable of recovering from large deformations quickly and forcibly, and can be, or already is, modified to a state in which it is essentially insoluble, (but can swell) in boiling solvents, such as Benzene, MEK,

etc. A rubber in its modified state, free of dilutants, retracts within one minute, to less than 1.5 times its original length after being stretched at room temperature (20-27°C) to twice its length.

Types of Insulation & Jackets

Thermosetting....

Butyl

(A polymer of isobutylene and some isoprene) (Gr-I) Ozone and water resistant. Now rarely used.

Styrene Butadiene (SBR)

Control cable and low voltage power cable insulations and jackets—water resistant (initially known as "BUNA-S" and "GRS") Limited use.

Ethylene-Propylene (EPR, EPM, EPDM)

600V and H.V. power cable insulation (90°C and 105°C). Excellent weathering and ozone resistance. Control and Power Cable insulation.

Crosslink Polyethylene (XLP, XLPE, X-LINK PE)

H.V. power and control cable insulation (90°C). Special appliance wiring material (125°C).

Chlorinated Polyethylene (CPE)

Available in thermoplastic and thermosetting versions. Both types exhibit good resistance to oils and chemicals. 0-600V insulation, flexible cord and portable power cable jacket.

Silicone Rubbers (150°C and 200°C)

High temperature insulations and some cable jackets, oil resistant.

Natural Rubber (Rubber Tree Hevea Brasiliensis) (75°C)

Insulation and jacket constituent for low temperature. Retractable cords, Control Cables. Now rarely used.

Polyisoprene Rubber

Synthetic "Natural rubber"

Polyurethane (121°C)

Thin wall cable jackets—abrasion, ozone, oil and fungus resistant.

Nitrile-Butadiene (NBR, Nitrile, "BUNA-N" 90°C)

Used in a colloidal blend with PVC for cable jackets where it is known as NBR/PVC or OZO.

Latex

Natural Rubber in water emulsion. Obsolete.

Chlorosulfonated polyethylene (CP, CSM, CSPE)

(90°C or 105°C)

Cable insulations and jackets—ozone and oil resistant.

Polychloroprene (Neoprene) CR (75°C or 90°C)

Cable insulation and jackets—ozone and oil resistant.

Thermoplastic....

Polyvinyl Chloride (Vinyl, PVC) (-45°C-105°C)

Conventional plasticized, semi-rigid, "Irradiated" versions used as insulation (through 1kV) and jackets.

Polyethylene (P.E., Poly)

Low density LDPD (75°C) or High density HDPE (90°C) versions. Communication and high frequency cable insulations and jackets. Control cable and 600V power cable insulations and jackets.

Crystalline Propylene/Ethylene Copolymer

(Polypropylene) PP (90°C)

Communication cable insulation.

Chlorinated Polyethylene (CPE)

Control and power cable jackets; flame resistant.

Polysulfone (-65°C +130°C)

Thin wall (.004"-0.005"). Insulations on small wire. (Poor resistance to many solvents)

Thermoplastic Elastomers (TPE) (90°C)

Relatively new material called Thermoplastic "rubber." Used as cable insulation and as insulation and jacket for flexible and other cords. Exhibits many characteristics of true rubber materials.

Polyurethane PU (75°C)

Thin wall cable jackets; abrasion, ozone, oil and fungus resistant.

Polyimide (Kapton)

Laminated to FEP and used as heat sealable tape - does not burn, high abrasion resistance. Specialized use for high temperature cables.

Polyamide (Nylons)

Used for mechanical and chemical protection up to 105°C over PVC or PE insulations.

Type 6

Poly caprolactan—standard nylon used on a conductor as a protective jacket.

Type 610 or 612

Zytel 33,37,153, and 157—nylon used on insulated conductors as a protective jacket. Some have certain moisture retraction properties.

Type 66

Used as medium grade insulation shapes.

Copolymer

Two or more of the above types.

Fluorocarbon (Fluoropolymer)

TFE	(Tetrafluoroethylene, Teflon) 260°C applied by RAM extrusion or sintered tapes over silver or nickel plated wire.
FEP	(Polytetrafluoroethylene/ Hexafluoropropylene) 200°C Thermoplastic: used for high temperature wires and miniature coaxial cables.
PFA	(Perfluoroalkoxy) 260°C Thermoplastic: insulation and jackets for high temperature cables in aircraft, oil wells, etc.
E-CTFE	(Ethylene chlorotrifluoroethylene) Thermoplastic: Halar 150°C. Cathodic protection wire, nuclear control and instrumentation cables, mass transportation wiring, thermo-couple wire.
ETFE	(Ethylene-Tetrafluoroethylene) TEFZEL Thermoplastic: 150°C. Computer back panel wiring.
PCTFE	(Poly and Chlorotrifluoroethylene) 135°C. Thermoplastic: Hook up wires.
PVF ₂	(Polyvinylidene Fluoride) KYNAR 135°C. Thermoplastic: Computer back panel wiring (silver plated wire).

ASSEMBLY OPERATIONS

Cord Twisters (30",42" and 60")

Individual reels of conductor and fillers, if necessary, are placed in payoff reels behind the machine. Conductors and fillers are then run through a guide, to form a round cable. The cable is taken up on a rotating reel which imparts the desired lay in the cable.

These machines are used for small flexible cords, small specialty cables, and telephone cable groups. Concentric assemblies of 19 wires, and greater, as well as large size nylon jacketed conductors, are not assembled in this type of machine.

Rigid Frame Cablers (6, 11, 19, 30 and 36 Cradle)

Individual reels of conductors and fillers are placed in payoff cradles, perpendicular to a long, heavy steel tube. The cradles are fixed to and spaced parallel in layers completely around this horizontal heavy steel tube. The conductors are run by guide pulleys along the steel tube and through a guide plate at the front or take-up end of the machine to form a patterned cable. Lay is imparted by rotation of the cradles and the heavy steel tube. The round twisted cable is taken up by a fixed take-up reel.

These machines are used for control cables, and telephone cable groups. Concentric assemblies of 19 conductors and greater, as well as nylon jacketed conductors, are not normally assembled in this type of machine. The larger cradle machines are used to assemble telephone groups into a completed telephone cable core.

Planetary Cabler (6, 18, 24 and 37 Cradle)

Action of machine and formation of cables is exactly the same as for the rigid frame except that twisting of the conductors is reduced.

These machines are used to assemble concentric strand conductors, groups in large telephone cables, and large size nylon jacketed conductors.

Twinners—Single & Double Twist

A wooden bow equipped with roller eyes, guides one conductor along its length and flies over the other conductor reel as it pays off, thus twisting the two conductors together.

These machines are used to twin pairs for control and telephone cables.

Quadruplers

Operates on the same principle as "twinners" except up to four conductors may be assembled.

These machines may be used to twin heavy wire, star quads, pair quads, and large flexible cords.

Rigid Frame & Cord Twister Actions vs. Planetary Twinning & Quad Actions

The rigid frame type actions impart a torsional twist to the individual conductor, which is residual

The planetary type actions impart a torsional twist in the conductor opposite to the torsional twist caused by cabling and the net residual torsional twist is zero.

Twisters (30", 48", 60")

Similar in action to a cord twister except that a rotating bow replaces the tumbling action of the take-up reel.

SHIELDING and ARMORING

Metallic or semi-conducting material applied over bare or insulated conductors, pairs, etc., or the cable core. The distinction between shielding and armoring is blurred. All armoring offers some degree of shielding. Certain types of shielding also function as armor.

Purpose of Shielding

High Voltage Cable	Prevent corona Surge protection Fault path provision
Control Cable	Provide circuit isolation Prevent noise interference Surge protection Contain intelligence
Communication Cable	Prevent noise interference Surge protection Lightning protection
Purpose of Armoring (all cable types)	<ul style="list-style-type: none"> • Mechanical protection • Mechanical strength • Moisture sealing

Types of Shielding & Armoring

Braid (16 carrier and 24 carrier)

Wardwell & N.E. Butt Co. Machines. A double serving of uninsulated wires interlocking in a two over-two under pattern. The second serving is applied in the reverse direction from the first.

Serve (8 carrier & 12 carrier)

A single serving of uninsulated wires applied in one direction.

Braid & Serve Materials

Shielding ____ #26,#28,#30,#32,#34 and #36 AWG bare or tinned copper.

Armoring ____ #26 or #28 AWG Aluminum, Bronze, or Steel plus #30 AWG steel.

Helical Metal Tape

A flat metal tape, applied with overlap, around pairs, triples, etc. cable core, or inner jacket.

Helical Metal Tape

Shielding ____ .003" and .005" copper or .004" Aluminum

Armoring ____ .005" and .010" Bronze

Film/Foil Tape

A flat polyester supported foil tape, applied with overlap, around pairs, triples, etc., cable core, or inner jacket. A drain wire is normally used with this type of shield for ease of terminating.

Film/Foil Tape Shielding Materials

Copper and aluminum laminated to polyester film. Thickness of foil is .00035", .0005" or .001". Polyester thickness is .0005", .001" or .002".

Longitudinal Corrugated Tape Shield

A flat tape is corrugated at right angles to its length and then formed into a cylinder, around a cable core or inner jacket. The tape may be coated on one or both sides for sealing to the sheath and itself.

Longitudinal Corrugated Tape Materials

Shielding ____ .005" copper, .008" aluminum

Armoring ____ .010" copper; .002" copper/.002" stainless/.002" copper composite; or welded seam .010" steel.

Strip

A serving of flat strips of metal applied with open spacing over cable core or inner jacket. Strip thickness and width vary depending on application. .012" thick x .125" wide is typical.

Strip Materials

Shielding—Copper

Armoring—Steel

Parkway Tape Armor

A flat metal tape is applied with an open lap over the cable core or inner jacket.

A duplicate second tape is applied centered over the opening of the first tape.

Parkway Taping Armoring Materials

.010" or .020" mild steel.

Interlock Armoring

A .020" to .030" thick strip of mild steel or aluminum is pre-formed and spiraled around the cable core. Each turn being "interlocked" with the preceding turn.

Round Wire Armoring

High tensile strength round steel wires are spiraled, close spaced, around the cable for mechanical protection or strength.

Steel wire sizes vary from #24 through #8 solid.

COLOR CODING

Used to identify conductors for point to point wiring and for circuit diagrams. Color codes are used to establish a standard for use by different manufacturers.

The first color code used colored tracers in a solid colored braid. Most control cable color codes are adaptations of this method. Later for ease and convenience, ink printed versions were developed.

Telephone requirements established special color codes.

Color Codes (ICEA Methods)

ICEA/NEMA Method 1

Colored insulation with contrasting ink tracers as required. Six different insulation colors and four different colored ink tracers are used to provide positive identification through 21 conductors. The same identification sequence is repeated for cables containing more than 21 conductors.

ICEA/NEMA Method 2

A neutral colored compound is used with single or double spiral ink tracers as required to provide positive identification through 21 conductors. The identification sequence is repeated for cables containing more than 21 conductors.

ICEA/NEMA Method 3

A neutral or single colored insulation compound is surface ink printed with both conductor number and color designation to provide positive identification through 21 conductors. The identification sequence is repeated for cables containing more than 21 conductors.

ICEA/NEMA Method 4

A neutral or single colored insulation compound is surface ink printed with conductor number to provide positive conductor identification through 21 conductors. The identification sequence is repeated for cables containing more than 21 conductors.

ICEA/NEMA Method 5

A color coding using braids. Also sometimes specified using colored insulation and contrasting tracers as an extension of Method 1 to eliminate duplicate conductors. Up to 127 positive conductor coding are available with this method.

Usually specified as per:

ICEA S-61-402 Table 5-1 or

ICEA S-19-81 Table 5-2

ICEA/NEMA Method 6

A color coding whereby one conductor in each layer is identified by a braid, tape, ridge, stripe or color.

ICEA/NEMA Paired Color Code

A coding whereby one leg of all pairs is coded white and its mate is coded in accordance with the first 21 conductors of Method 1, omitting white and repeating the sequence as necessary.

Telephone Paired Color Code

Five colors are paired with each of five mate colors to give twenty-five identified pairs. The color sequences are repeated for more than twenty-five pairs using colored binder strings for group identification.

Note: UL and the NEC restrict the use of green and white as colors and stripes. Special color codes are available to meet these requirements. One method is ICEA Method E-2 which is similar to Method 1 and ICEA Method E-4 which is similar to Method 2.

ICEA METHOD 1, Table E-1

(Colored Compounds with Tracers)

Conductor Number	Background or Base Color	Tracer Color
1*	Black	—
2	White	—
3	Red	—
4	Green	—
5	Orange	—
6	Blue	—
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Red	Green
21	Orange	Green

*This conductor is in the inside of the assembly.

ICEA METHOD 2, Table E-1

(Neutral Colored Compound with Tracers)

Conductor Number	First Tracer Color (Wide Tracer)	Second Tracer Color (Narrow Tracer)
1*	Black	—
2	White	—
3	Red	—
4	Green	—
5	Orange	—
6	Blue	—
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Red	Green
21	Orange	Green

*This conductor is in the inside of the assembly.

ICEA METHOD 3

(Neutral or single color compound with surface printing of numbers and color designations)

Conductor Number	Printed Legend
1*	1-Black
2	2-White
3	3-Red
4	4-Green
5	5-Orange
6	6-Blue
7	7-White-Black
8	8-Red-Black
9	9-Green-Black
10	10-Orange-Black
11	11-Blue-Black
12	12-Black-White
13	13-Red-White
14	14-Green-White
15	15-Blue-White
16	16-Black-Red
17	17-White-Red
18	18-Orange-Red
19	19-Blue-Red
20	20-Red-Green
21	21-Orange-Green

*This conductor is in the inside of the assembly.

ICEA METHOD 4

(Neutral or single color compound with surface printing of numbers)

Conductor Number	Printed Legend
1*	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21

*This conductor is in the inside of the assembly.

ICEA METHOD 5

(Colored Compounds with Tracers)

Cond. Number	Back-ground or Base Color	First Tracer Color	Second Tracer Color	Cond. Number	Back-ground or Base Color	First Tracer Color	Second Tracer Color	Cond. Number	Back-ground or Base Color	First Tracer Color	Second Tracer Color
1*	Black	—	—	46	Red	White	Blue	91	Blue	Orange	—
2	White	—	—	47	Green	Orange	Red	92	Black	Blue	—
3	Red	—	—	48	Orange	Red	Blue	93	White	Blue	—
4	Green	—	—	49	Blue	Red	Orange	94	Red	Blue	—
5	Orange	—	—	50	Black	Orange	Red	95	Green	Blue	—
6	Blue	—	—	51	White	Black	Orange	96	Orange	Blue	—
7	White	Black	—	52	Red	Orange	Black	97	Yellow	—	—
8	Red	Black	—	53	Green	Red	Blue	98	Yellow	Black	—
9	Green	Black	—	54	Orange	Black	Blue	99	Yellow	White	—
10	Orange	Black	—	55	Blue	Black	Orange	100	Yellow	Red	—
11	Blue	Black	—	56	Black	Orange	Green	101	Yellow	Green	—
12	Black	White	—	57	White	Orange	Green	102	Yellow	Orange	—
13	Red	White	—	58	Red	Orange	Green	103	Yellow	Blue	—
14	Green	White	—	59	Green	Black	Blue	104	Black	Yellow	—
15	Blue	White	—	60	Orange	Green	Blue	105	White	Yellow	—
16	Black	Red	—	61	Blue	Green	Orange	106	Red	Yellow	—
17	White	Red	—	62	Black	Red	Blue	107	Green	Yellow	—
18	Orange	Red	—	63	White	Orange	Blue	108	Orange	Yellow	—
19	Blue	Red	—	64	Red	Black	Blue	109	Blue	Yellow	—
20	Red	Green	—	65	Green	Orange	Blue	110	Black	Yellow	Red
21	Orange	Green	—	66	Orange	White	Red	111	White	Yellow	Red
22	Black	White	Red	67	Blue	White	Red	112	Green	Yellow	Red
23	White	Black	Red	68	Black	Green	Blue	113	Orange	Yellow	Red
24	Orange	Black	White	69	White	Green	Blue	114	Blue	Yellow	Red
25	Blue	Black	White	70	Red	Green	Blue	115	Black	Yellow	White
26	Red	Black	White	71	Green	White	Red	116	Red	Yellow	White
27	Orange	Black	White	72	Orange	Red	Black	117	Green	Yellow	White
28	Black	Red	Green	73	Blue	Red	Black	118	Orange	Yellow	White
29	White	Red	Green	74	Black	Orange	Blue	119	Blue	Yellow	White
30	Red	Black	Green	75	Red	Orange	Blue	120	Black	Yellow	Green
31	Green	Black	Orange	76	Green	Red	Black	121	White	Yellow	Green
32	Orange	Black	Green	77	Orange	White	Green	122	Red	Yellow	Green
33	Blue	White	Orange	78	Blue	White	Green	123	Orange	Yellow	Green
34	Black	White	Orange	79	Red	White	Orange	124	Blue	Yellow	Green
35	White	Red	Orange	80	Green	White	Orange	125	Black	Yellow	Blue
36	Orange	White	Blue	81	Blue	Black	Green	126	White	Yellow	Blue
37	White	Red	Blue	82	Orange	White	—	127	Red	Yellow	Blue
38	Black	White	Green	83	Green	Red	—				
39	White	Black	Green	84	Black	Green	—				
40	Red	White	Green	85	White	Green	—				
41	Green	White	Blue	86	Blue	Green	—				
42	Orange	Red	Green	87	Black	Orange	—				
43	Blue	Red	Green	88	White	Orange	—				
44	Black	White	Blue	89	Red	Orange	—				
45	White	Black	Blue	90	Green	Orange	—				

*This conductor is in the inside of the assembly.

ICEA METHOD 1, TABLE E-2

(Colored Compound with Tracers)

Conductor Number	Background or Base Color	Tracer Color	Conductor Number	Background or Base Color	Tracer Color
*1	Black		19	Orange	Blue
2	Red		20	Yellow	Blue
3	Blue		21	Brown	Blue
4	Orange		22	Black	Orange
5	Yellow		23	Red	Orange
6	Brown		24	Blue	Orange
7	Red	Black	25	Yellow	Orange
8	Blue	Black	26	Brown	Orange
9	Orange	Black	27	Black	Yellow
10	Yellow	Black	28	Red	Yellow
11	Brown	Black	29	Blue	Yellow
12	Black	Red	30	Orange	Yellow
13	Blue	Red	31	Brown	Yellow
14	Orange	Red	32	Black	Brown
15	Yellow	Red	33	Red	Brown
16	Brown	Red	34	Blue	Brown
17	Black	Blue	35	Orange	Brown
18	Red	Blue	36	Yellow	Brown

*This conductor is in the inside of the assembly Note: No green or white conductors or stripes are present.

ICEA METHOD 1, TABLE E-2

(Neutral Colored Compound with Tracers)

Conductor Number	First Tracer Color e.g. Wide Tracer	Second Tracer Color e.g. Narrow Tracer	Conductor Number	First Tracer Color e.g. Wide Tracer	Second Tracer Color e.g. Narrow Tracer
*1	Black		19	Orange	Blue
2	Red		20	Yellow	Blue
3	Blue		21	Brown	Blue
4	Orange		22	Black	Orange
5	Yellow		23	Red	Orange
6	Brown		24	Blue	Orange
7	Red	Black	25	Yellow	Orange
8	Blue	Black	26	Brown	Orange
9	Orange	Black	27	Black	Yellow
10	Yellow	Black	28	Red	Yellow
11	Brown	Black	29	Blue	Yellow
12	Black	Red	30	Orange	Yellow
13	Blue	Red	31	Brown	Yellow
14	Orange	Red	32	Black	Brown
15	Yellow	Red	33	Red	Brown
16	Brown	Red	34	Blue	Brown
17	Black	Blue	35	Orange	Brown
18	Red	Blue	36	Yellow	Brown

*This conductor is in the inside of the assembly Note: Green or white are not used.

ICEA PAIRED COLOR CODE

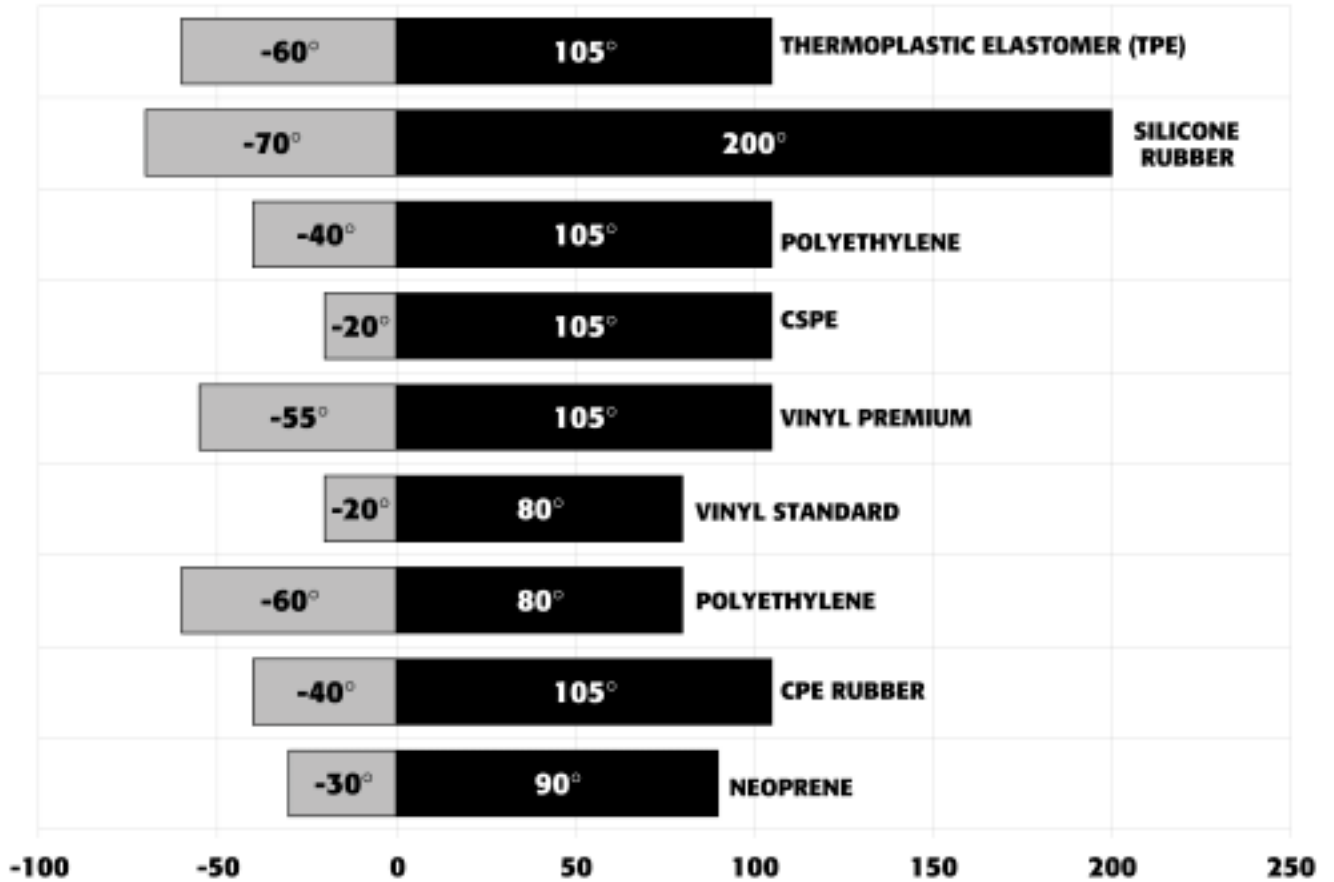
Pair Number	Leg #1 Color	Tracer	Leg #2 Color
1	Black	—	White
2	Red	—	White
3	Green	—	White
4	Orange	—	White
5	Blue	—	White
6	White	Black	White
7	Red	Black	White
8	Green	Black	White
9	Orange	Black	White
10	Blue	Black	White
11	Black	White	White
12	Red	White	White
13	Green	White	White
14	Blue	White	White
15	Black	Red	White
16	White	Red	White
17	Orange	Red	White
18	Blue	Red	White
19	Red	Green	White
20	Orange	Green	White
21	Black	—	White

TELEPHONE PAIRED COLOR CODE

Pair Number	Tip Conductor	Ring Conductor	Pair Number	Tip Conductor	Ring Conductor
1	White	Blue	14	Black	Brown
2	White	Orange	15	Black	Slate
3	White	Green	16	Yellow	Blue
4	White	Brown	17	Yellow	Orange
5	White	Slate	18	Yellow	Green
6	Red	Blue	19	Yellow	Brown
7	Red	Orange	20	Yellow	Slate
8	Red	Green	21	Violet	Blue
9	Red	Brown	22	Violet	Orange
10	Red	Slate	23	Violet	Green
11	Black	Blue	24	Violet	Brown
12	Black	Orange	25	Violet	Slate
13	Black	Green			

In cables having more than 25 pairs, each group of 25 pairs shall be distinguished by colored or imprinted binders.

Nominal Temperature Operating Ranges Temperature °C



Properties of Rubber Used for Insulations

Properties/Resistance	SBR	Natural	Polybutadiene	Neoprene	CSPE	NBR	EPDM	Butyl	Silicon	XLP
Abrasion	G-E	E	E	G-E	G	G-E	G	F-G	F	G-E
Acid	F-G	F-G	F-G	G	E	G	G-E	E	F-G	E
Alcohol	F	G	F-G	F	G	E	P	E	G	E
Alkali	F-G	F-G	F-G	G	E	F-G	G-E	E	F-G	E
Benzol, Toluol	P	P	P	P-F	F	G	F	F	P	G
Degreaser Solvent	P	P	P	P	P-F	P	P	P	P-F	G
Electrical Properties	E	E	E	F	G	P	E	E	O	E-O
Flame	P	P	P	G	G	P	P	P	F-G	E
Gasoline, Kerosene	P	P	P	G	F	E	P	P	P-F	G
Heat	F-G	F	F	G	E	G	E	G	O	G
Low Temp. Flexibility	F-G	G	E	F-G	F	F-G	G-E	G	O	G
Nuclear Radiation	F-G	P	P	F-G	G	F-G	G	P	E	E
Oil	P	P	P	G	G	G-E	F	P	F-G	G-E
Oxidation	F	F	G	G	E	F	G	E	E	E
Ozone	P	P	P	G	E	P	E	E	O	E
Water	G-E	G-E	E	G	G-E	G-E	G-E	G-E	G-E	G-E
Weather, Sun	F	F	F	G	E	F-G	E	E	O	G-E

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

Properties of Plastic Used for Insulations

Properties/Resistance	PVC	L.D.P.E.	H.D.P.E.	Polypropylene	Polyurethane	Nylon	Teflon
Abrasion	F-G	F-G	E	F-G	O	E	G-E
Acid	G-E	G-E	G-E	E	F	P-F	E
Alcohol	G-E	E	E	E	P	P	E
Alkali	G-E	G-E	G-E	E	F	E	E
Benzol, Toluol	P-F	P	P	P-F	F	G	E
Degreaser Solvent	P-F	P	P	P	P	G	E
Electrical Properties	F-G	E	E	E	P-F	F	E
Flame	E	P	P	P	P	P	O
Gasoline, Kerosene	G-E	P-F	P-F	P-F	F	G	E
Heat	G-E	G	E	E	G	E	O
Low Temp. Flexibility	P-G	G-E	E	P	G	G	O
Nuclear Radiation	P-F	G	G	F	G	F-G	P-F
Oil	E	G-E	G-E	E	E	E	O
Oxidation	E	E	E	E	E	E	O
Ozone	E	E	E	E	E	E	E
Water	E	E	E	E	P	P-F	E
Weather, Sun	G-E	E	E	E	F-G	E	O

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

<p style="text-align: center;">Check List for Single Conductor</p> <ul style="list-style-type: none"> <input type="checkbox"/> Conductor: Size, Stranding, Bare, Tinned, or Overtinned <input type="checkbox"/> Insulation: Type, Wall Thickness, Color, Temperature, Voltage <input type="checkbox"/> Jacket (if present): Type, Wall Thickness, Color, Temperature <input type="checkbox"/> Printing <input type="checkbox"/> Put-Up <input type="checkbox"/> UL and/or CSA Listings Required <input type="checkbox"/> Special Requirements <input type="checkbox"/> Company or Industry Specs 	<p style="text-align: center;">Check List for High Voltage Cable</p> <ul style="list-style-type: none"> <input type="checkbox"/> Conductor: Size, Stranding, Bare or Tinned <input type="checkbox"/> Strand Shield: Semi-conducting Tape or Extruded shield <input type="checkbox"/> Insulation: Type, Voltage, Wall Thickness (Grounded/Ungrounded) Temperature <input type="checkbox"/> Insulation Shield (if present): <ul style="list-style-type: none"> a.) Semi-conducting; Tape or Extruded Shield b.) Metal Tape; Metal Braid; Metal Wire Shields <input type="checkbox"/> Jacket: Type, Wall Thickness, Color, Temperature <input type="checkbox"/> Printing on Jacket <input type="checkbox"/> Put-Up <input type="checkbox"/> UL Listing Required <input type="checkbox"/> Special Requirements <input type="checkbox"/> Company or Industry Specs
<p style="text-align: center;">Check List for Multi-Conductor Cable</p> <ul style="list-style-type: none"> <input type="checkbox"/> Conductor: Number, Size, Stranding, Bare or Tinned <input type="checkbox"/> Insulation: Type, Wall Thickness, Color, Temperature, Voltage <input type="checkbox"/> Jacket (if present): Type, Wall Thickness, Color, Temperature <input type="checkbox"/> Color Coding <input type="checkbox"/> Assembly <input type="checkbox"/> Cable Binder: Type, Overlap, Coverage <input type="checkbox"/> Shield: Type, Overlap <input type="checkbox"/> Drain Wire (if present): Size, Stranding Bare or Tinned <input type="checkbox"/> Overall Jacket: Type, Wall Thickness, Temperature, Color <input type="checkbox"/> Printing on Jacket <input type="checkbox"/> Put-Up <input type="checkbox"/> UL and/or CSA Listings Required <input type="checkbox"/> Special Requirements <input type="checkbox"/> Company or Industry Specs 	<p style="text-align: center;">Check List for Paired Cable</p> <ul style="list-style-type: none"> <input type="checkbox"/> Pairs: Number <input type="checkbox"/> Conductor: Size, Stranding, Bare or Tinned <input type="checkbox"/> Insulation: Type, Wall Thickness, Temperature, Voltage or Electrical Requirements <input type="checkbox"/> Color Coding <input type="checkbox"/> Twinning: Direction and Length of Lay <input type="checkbox"/> Pair Shields: Type, Overlap, Coverage, Isolating <input type="checkbox"/> Drain Wire (if present): Size, Strand, Bare or Tinned <input type="checkbox"/> Jacket (over pairs; over shields): Type, Wall Thickness, Color <input type="checkbox"/> Jacket Color Code <input type="checkbox"/> Assembly <input type="checkbox"/> Cable Binder: Type, Overlap <input type="checkbox"/> Shield: Type, Overlap <input type="checkbox"/> Drain Wire (if present): Size, Stranding, Bare or Tinned <input type="checkbox"/> Overall Jacket: Type, Wall Thickness, Temperature, Color <input type="checkbox"/> Print on Jacket <input type="checkbox"/> Put-Up <input type="checkbox"/> UL and/or CSA Listings Required <input type="checkbox"/> Company or Industry Specs

Glossary

AWG-Abbreviation for American Wire Gauge.

AWM-Designation for appliance wiring material.

Alternating Current-Electric current that continually reverses its direction. Is expressed in cycles per second (hertz or Hz).

Ambient Temperature-The temperature of the medium (gas, liquid or earth) surrounding an object.

American Mustang-A premium grade thermoset cord, UL listed as SOOW or SJOOW, CSA SOOW and SJOOW.

American Wire Gauge (AWG)-A standard system for designating wire diameter. Also referred to as the Brown and Sharpe (B&S) wire gauge.

Ampacity-See Current Carrying Capacity.

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

Anneal-Relief of mechanical stress through application of heat and gradual cooling. Annealing copper renders it soft and less brittle.

Audio Frequency-The range of frequencies audible to the human ear. Usually 20-20,000 Hz.

Braid-A fibrous or metallic group of filaments interwoven in cylindrical form to form a covering over one or more wires.

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

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

Cabbling-The twisting together of two or more insulated conductors to form a cable.

Capacitance-The ability of a dielectric material between conductors to store electricity when a difference of potential exists between the conductors. The unit of measurement is the farad, which is the capacitance value that will store a charge of one coulomb when a one-volt potential difference exists between the conductors. In AC, one farad is the capacitance value that will permit one ampere of current when the voltage across the capacitor changes at a rate of one volt per second.

Circuit (Electric)-The complete path of an electrical current. When the continuity is broken, it is called an open circuit; when continuity is maintained, it is called a closed circuit.

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

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

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

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.

Conductor-An uninsulated wire suitable for carrying electrical current.

Contacts-The parts of the connector that actually carry the electrical current, and that touch the equivalent parts in the mating connector.

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

Cord-A flexible insulated cable.

Corona-Ionization of air surrounding a conductor caused by the influence of high voltage. Causes deterioration of insulation materials.

Crazing-The minute cracks on the surface of plastic materials.

CSA-Abbreviation for Canadian Standards Association, a non-profit, independent organization that operates a listing service for electrical and electronic materials and equipment. The Canadian counterpart of the Underwriters Laboratories.

Current Carrying Capacity-The maximum current an insulated conductor can safely carry without exceeding its insulation and jacket temperature limitations. It is dependent on the installation conditions.

Decibel (db)-A unit that expresses differences of power or voltage level. It is used to express power loss in passive circuits or cables.

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

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

Drain Wire-In a cable, the uninsulated wire laid over the shield component or components and used as a ground connection.

Drawing-In wire manufacture, pulling the metal through a die or series of dies to reduce diameter to a specified size.

EMI-Abbreviation for electromagnetic interference.

Eccentricity-Like concentricity, a measure of the center of a conductor's location with respect to the circular cross section of the insulation. Expressed as a percentage of displacement of one circle within the other.

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

Farad-A unit of electrical capacitance.

Filler (1)-A material used in multiconductor 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 resist the propagation of flame once the heat source is removed.

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

Frequency-The number of times an alternating current repeats its cycle in one second.

G-An industry designation for a 2kV portable power cable consisting of 2 - 4 insulated conductors with ground wires placed in the valleys for use in mines and similar applications.

G-GC-An industry designation for a 2kV portable power cable consisting of 3 insulated conductors with ground wires, 2 ground wires, and a ground check conductor. For use in mines and similar applications.

Gauge-A term used to denote the physical size of a wire.

Ground-An electrical term meaning to connect to the earth or other large conducting body to serve as an earth, thus making a complete electrical circuit.

HPD-Heater cord with thermoset insulation and cotton or rayon braid overall.

HPN-Parallel heater cord.

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.

Hertz (Hz)-A term replacing cycles-per-second as an indication of frequency.

Hi-Pot-A test designed to determine the highest voltage that can be applied to a conductor without breaking through the insulation.

Hz-Abbreviation for hertz.

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 R and reactance X, 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 a dielectric in radio frequency cable.

Jacket-An outer non-metallic protective covering applied over an insulated wire or cable.

Jumper Cable-A short flat cable interconnecting two wiring boards or devices.

Lay-The length measured along the axis of a wire or cable required for a single strand (in stranded wire) or conductor (in cable) to make one complete turn about the axis of the conductor or cable.

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

MTW-Thermoplastic insulated machine tool wire.

Multiconductor-More than one conductor within a single cable complex.

Mylar-A synthetic compound with high dielectric qualities made by DuPont and used extensively in the wire and cable industry in tape form.

NEMA-Abbreviation for National Electrical Manufacturers Association.

Ohm-A unit of electrical resistance.

OSHA-Abbreviation for Occupational Safety and Health Act, specifically the Williams-Steiger Law passed in 1970 covering all factors relating to safety in places of employment.

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

Potting-The sealing of a cable termination or other component with a liquid that cures into an elastomer.

Primary Insulation-The first layer of non-conductive material applied over a conductor, whose prime function is to act as electrical insulation.

Put-Up-Packaging of finished wire or cable by size and length.

PVC-Abbreviation for polyvinyl chloride.

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

REA-Abbreviation for Rural Electrification Administration, which is part of the U.S. Dept. of Agriculture. REA establishes specifications and provides approval for telephone station wire and power cables.

Resistance-A measure of the difficulty in moving electrical current through a medium when voltage is applied. It is measured in ohms.

RFI-Abbreviation for radio frequency interference.

S-Heavy Duty, rubber-insulated portable cord. Standard copper conductors with separator and individual rubber insulation. Two or more color-coded conductors cabled with filler, wrapped with separator and rubber jacketed overall 600V.

SEO-Same construction as STO, except insulation and jacket are made of Thermoplastic Elastomer Rubber (TPE) 600V.

SEOW-Same construction as SEO, except suitable for outdoor use. Usually UL listed for continuous submersion in water 600V.

SEOWW-Same construction as SEOW, except with oil resistant insulation.

SJ-Junior hard service rubber-insulated pendant or portable cord. Same construction as SJT except insulation and jacket is thermoset (rubber) 300V.

SJE-Same construction as SJT, except insulation and jacket made of Thermoplastic Elastomer Rubber (TPE) 300V.

SJEO-Same construction as SJO, except insulation and jacket made of Thermoplastic Elastomer Rubber (TPE).

SJEOW-Same construction as SEOW except 300 volt rated.

SJO-Same as SJ, but oil-resistant outer jacket. Can also be made "water resistant." 300V, 60°C, 75°C, 90°C or 105°C.

SJOOW-Same as SOOW except 300 volt rated.

SJT-Junior hard service thermoplastic conductors with overall thermoplastic jacket, 300V, 60°C, 75°C, 90°C or 105°C.

SJTO-Same as SJT, but oil-resistant thermoplastic outer jacket.

SLC-Stage Lighting Cable. A 600 volt single conductor cable for use with indoor and outdoor stages, fairs and carnivals.

SO-Hard service cord. Same construction as type S, except oil-resistant thermoset jacket. 600V, 60°C to 105°C.

SOW-Same as SO except suitable for outdoor use.

SOOW-Same as SOW except oil resistant insulation.

SP-1-All rubber, parallel-jacketed, two-conductor light duty cord for pendant or portable use. 300V.

SP-2-Same as SP-1, but heavier construction, with or without third conductor for grounding purposes. 300V.

SP-3-Same as SP-2, but heavier construction for refrigerators or room air conditioners. 300V.

SPE-Same construction as SP-1, except insulation and jacket made of Thermoplastic Elastomer Rubber (TPE).

SPT-1-Same as SP-1, except all-thermoplastic, 300V. With or without third conductor for grounding.

SPT-2-Same as SP-2, except all-thermoplastic. 300V. With or without third conductor for grounding.

SPT-3-Same as SP-3, except all-thermoplastic. 300V. With or without third conductor for grounding.

ST-Hard service cord, jacketed. Same as type S, except all-plastic construction. 600V, 60°C to 105°C.

STO-Same as ST, but with oil-resistant thermoplastic outer jacket. 600V, 60°C to 105°C.

SV-Vacuum cleaner cord, rubber-insulated with rubber jacket, rated at 300V.

SVE-Same construction as SV, except insulation and jacket made of Thermoplastic Elastomer (TPE).

SVT-Same as SV, except all-plastic construction. With or without third conductor for grounding purposes only. 300V, 60°C to 105°C.

Separator-Pertaining to wire and cable, a layer of insulating material such as textile paper, mylar, etc., which is placed between a conductor and its dielectric, between a cable jacket and the components it covers, or between various components of multiple conductor cable. It can be utilized to improve stripping qualities and/or

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flexibility, or can offer additional mechanical or electrical protection to the components it separates.

Shield-A tape serve, or braid of metal, usually copper, aluminum, or other conducting material, placed around or between electric circuits or cables or their components to contain any unwanted radiation, or to keep out an unwanted interference.

Spacing-Distance between the closest edges of two adjacent conductors.

Spark Test-A test designed to locate pinholes in the insulation of a wire or cable by application of a voltage for a very short period of time while the wire is being drawn through a field of electrodes.

Spiral Wrap-The helical wrap of a tape or other material over a core or component.

Strand-A single uninsulated wire.

Stranded Conductor-A conductor composed of wires or groups of wires twisted together.

Surge-A temporary and relatively large increase in the voltage or current in an electric circuit or cable. Also called a transient.

TC-Tray Cable. Multi-conductor cable specifically approved for use installed in cable trays.

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

Thermoplastic-A material that softens and melts when heated and becomes firm on cooling.

Thermoset-A material that hardens or sets when heat is applied and that, once set, cannot be resoftened by heating. The application of heat cures or vulcanizes the material.

TPE-Abbreviation for Thermoplastic elastomer.

UL-Abbreviation for Underwriters Laboratories, a non-profit independent organization that operates a listing service for electrical and electronic materials and equipment.

Voltage-The term most often used in place of electromotive force, potential, potential difference, or voltage drop to designate the electrical pressure that exists between two points and is capable of producing a current when a closed circuit is connected between two points.

VW-1-A flammability rating established by Underwriters Laboratories for wires and cables that pass a specific vertical flame test, formerly designated FR-1.

W-UL designation for outdoor listed flexible cord that is tested for sunlight and weather requirements (e.g., STW).

W (Type)-An industry designation for a 2kV portable power cable consisting of 1 - 6 insulated conductors. For use in mines and similar severe duty applications.

Water Resistant-UL designation for cords that have an insulation on the individual conductors that passes UL requirements (e.g., ST Water Resistant or ST Dry 105°C, Water Resistant 60°C).

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