MAY/JUNE 1966

INSULATION DIRECTORY / ENCYCLOPEDIA ISSUE

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Section 3-19: Wire, Cable and Assemblies (Except Magnet Wire)

New Developments

◀ An insulated electrical conductor core, produced by the extrusion of a tube of polyethylene insulation which is simultaneously filled with a sodium conductor, has been made in various types for experimental 15-kv direct buried underground and aerial cables. Samples up to 138-kv have been made. The cables reportedly are more flexible, lighter in weight, and hold promise of being more economical than conventional cables. Larger cables are expected to weigh 50 percent less than conventional cables. The sodium metal is inherently so flexible that it can be used in solid form and therefore does not have to be stranded to achieve flexibility, regardless of conductor size.

One pound of sodium, costing about 17 cents, will conduct as much electrical current as 3½ pounds of copper or 1¾ pounds of aluminum. However, the insulated sodium conductor will be approximately 45 percent larger in diameter than a conventional insulated copper conductor. Sodium is highly reactive with oxygen and water but, when encased in the polyethylene insulation, it is said to be handled with ease and safety. Hazards encountered when the insulation is faulted have been found to be minimal according to tests carried out under actual usage conditions. Since sodium has virtually no mechanical strength, special terminations are required to permit the cable to be connected to equipment.

Product and process patent applications covering this new development have been filed by Union Carbide Corp.

◀ Epichlorohydrin elastomers for wire and cable jackets and other uses are made in two types, a homopolymer called CHR, and a copolymer. CHC, which is a copolymer of epichlorohydrin with ethylene oxide. Excellent ozone resistance, high impermeability to gases, superior chemical resistance, and low temperature flexibility are some of the features reported. B. F. Goodrich Chemical Co. has introduced the new rubbers under license from Hercules Inc.

◀ Polysulfone thermoplastic reportedly provides a tough, abrasion resistant wire insulation that maintains its electrical and mechanical properties from —150° to over 300°F for extended periods of time. The material also offers high temperature cut-through resistance as well as fabrication characteristics that permit thin coatings (down to 1 mil) to be extruded onto wire. Other features claimed include unusually good thermal stability, oxidation resistance, and self-extinguishing properties. The resin is supplied by Union Carbide Corp., Plastics Div.

◀ Trends noted by various wire producers include continued acceptance of high strength copper alloys, increasing usage of crosslinked polyethylene, and growing recognition on the part of suppliers for materials which not only provide improved properties but also which process readily. Hudson Wire Co. notes that in the ultra-fine stranded wire range where absolute reliability is required it is feasible to use pure silver wires instead of copper wires with protective coatings of silver or nickel plating. This allows for slightly increased conductivity (108%), the elimination of any possibility of corrosion, and 15% reduction in tensile strength compared with the equivalent construction of silver plated copper.

◀ A thermal barrier system for protecting communications cable cores from heat during cable manufacture is based on a foamable latex applied variously to metal or plastic tapes used as shields or wraps for the cable core. While the foam has relatively poor electric strength, it is so effective a thermal barrier that it avoids any high temperature requirement for a core wrap placed beneath it. The electrical function is provided by a low-cost plastic tape, such as polyethylene, with no danger that the heat of extrusion could impair its electric strength. The foamable latex coating may be foamed either by a pre-heating process immediately prior to the extrusion of the jacket or by the heat of extrusion itself. Test results indicate the most desirable form to be a metal tape coated on both sides with an adherent polyethylene copolymer and with the foamable coating on one side. This results in a cable with a jacket bonded to the metal shield. Supplier is Dow Chemical Co.

Metals which are used for armor provide many different types of physical protection. Properties of typical metals are shown in the tables on other pages.

Fillers, Insulation, And Jacketing Materials

As previously defined, a filler is used in multi-conductor cables to occupy the interstices formed by the assembly of the insulated conductors, thus forming a cable core of the desired shape, usually circular. Fibrous fillers such as jute and cotton, inorganic fillers such as asbestos and fiber glass, and plastic fillers such as polyethylene and PVC are commonly used.

Quite naturally, the *primary insulation* on a wire or cable is used for insulation purposes. In those cases where the primary insulation is the only covering, it may also be considered to be fulfilling jacketing functions. *Jacketing* provides protection against moisture, solvents, acids, alkalies, fungus, chemicals, heat, radiation, and physical abuse such as abrasion and cutting. Jacketing also holds cable elements together and prevents contact between shielding and ground.

The method of applying the insulation or jacketing material will influence end properties. Application methods include braiding, extruding, taping, and dip coating. Different forms of the same material may be applied by different methods with different properties resulting.

Nearly all of the materials used for primary insulation and jacketing have been described in other sections and readers should refer to sections 3-1, 3-2, 3-3, 3-4, 3-7, 3-10, 3-11, 3-12, 3-13, 3-15, and 3-16 for additional details. In some cases, information on magnet wires in section 3-18 would also apply. It also should be remembered that fibrous materials are often coated or impregnated. Highlights of important insulating and jacketing materials will be briefly mentioned in the discussion that follows with references to the sections in which additional general data may be found—since many of these materials are specially compounded for wires and cables, readers should consult the manufacturers for specific data.

Acrylic—available in fibrous form for yarn servings and braids. Acrylic coating and impregnant also available (mostly for other uses). Other synthetic fibers find greater use for wire and cable insulation than the acrylics. In general, acrylics offer desirable physical and electrical properties and good resistance to most chemicals and weathering. For special purpose insulation, acrylic elastomers can be used—they provide excellent ozone resistance and good aging properties but chemical resistance is spotty—see section 3-11.

Anodic Films—most of the publicity and possible potential for anodic film insulation (aluminum oxide coating on aluminum conductor) is concentrated in the magnet wire application area but some other wire applications have been suggested. The coating is thin, space-saving, inorganic, and resistant to extreme temperatures (3600°F melting point). Although anodic film insulated conductors can be bent and processed without rupturing the film, flexibility is limited relative to other insulations.

Asbestos—fibrous asbestos wire and cable insulation is used in the form of yarn servings, felts, lap, roving, and braid. Asbestos reinforced or combined with other materials also is used. Where space is important, asbestos papers and purified asbestos papers may be used. Commonly, felted asbestos insulated wires and cables are available with all-asbestos insulation, in combination with varnished cambric (where moisture is a factor), or in combination with a thermoplastic (for switchboard work). The asbestos felt is impregnated with either a flame and heat resisting compound or a flame, heat, and moisture resisting compound. Suitable for lower voltage work, asbestos provides excellent heat and radiation resistance, non-flammability, flexibility, and resistance to most chemical conditions. It is used for power cable, rheostat wire, apparatus cable, lead wire, range wire, appliance wires and cords, mining cable, and other applications where heat is a problem. See section 3-3.

Butyl (IIR-Isobutylene-Isoprene) Rubber—a polymer of isobutylene with small amounts of isoprene, this is an increasingly popular insulation and jacketing material. When properly compounded, butyl rubber is characterized by excellent resistance to oxidation and aging, exceptional ozone resistance, and very good electrical properties. Resistance to moisture, physical abuse, and chemicals is also good. Applications include low and high voltage power cables, apparatus and equipment leads, control cables, and various other cables. It is alkali-sensitive and may revert under hot, wet conditions. See section 3-11.

Cellulose Acetate — available in yarn form for wire servings and braids as well as in film form for taped insulation. These materials are characterized by very good electrical properties per unit thickness. They are non-corrosive with moderate to good resistance to chemicals. The film has been used for lead wire insulation. Moisture resistance is good. See sections 3-3 and 3-13.

Ceramic—ceramic insulations are available in the form of fibrous alumina-silica yarns for servings and braids and also in the form of coatings. Heat and radiation resistances are excellent. Manufacturers should be consulted in regard to film flexibility and uses. Ceramic beads are another form used to provide physical separation. See sections 3-3 and 3-16. Also see *mineral insulation* below.

Chlorosulfonated Polyethylene — this vulcanizable material has good electrical properties and exceptional resistance to ozone. It has very good resistance to oxidation by sunlight, weather, chemicals, and relatively high temperatures. Although resilience is generally lower than that of natural and synthetic rubbers at room temperature, it is equal or better at 212°F. It is relatively resistant to oils, flame, and moisture. It is being used in some instances for integral insulation jacket applications. See section 3-11.

Cotton—cotton is used for servings and braids. Flexibility and strength are good. Treatments are required to provide chemical and fungus resistance. Heat resistance is limited. See

the application. PVC is probably the most versatile of the lower cost, conventional temperature wire insulations in round and ribbon forms. See section 3-10.

A conductive vinyl is used in many cases where shielding and mechanical protection are obtained at the same time.

Rayon—this is a synthetic used for yarn serving and braid applications generally in the same applications where cotton can be used. See section 3-3.

SBR is a styrene-butadiene copolymer synthetic rubber characterized by good electrical properties and moisture resistance. Ozone resistance, physical properties, and chemical resistance are generally improved by blending with other materials. In this respect, it should be mentioned that both the synthetic and natural rubbers are not always used "straight" but can be blended with each other and other products in order to improve properties. Thus, this discussion runs the risk of over-generalization—wire and cable producers should be consulted for specific information. See section 3-11.

Silica—silica fibers produced from melted quartz offer properties similar to fiber glass but even higher heat resistance (above 2000°F). They offer possibilities as yarn servings. See section 3-3.

Silicone rubber—silicone rubber extrusions offer retention of good electrical properties, resilience, and flexibility after long-time heat aging at class 180 temperatures and higher. Excellent ozone resistance, low temperature flexibility, long life, low moisture absorption, weather resistance, radiation resistance, and corona resistance are other characteristics. Resistance to some oils, solvents, and strong acids is relatively poor. Aircraft wires, nuclear cable, lighting wire, power cable, control cable, shipboard cable, heat and cold appliance wires, lead wires, hook-up wire, ignition cable, fixture wire, and nuclear cable are uses.

In the field of high temperature wires and cables, these advantages mean longer service life, improved performance, safer operation, and savings in weight and space. While generally specified for 200°C continuous operation, silicone rubber has been known to maintain its physical and electrical properties after short time exposure at 315°C. Electrical properties remain stable over a range of temperature from extremely low to 250°C.

One of the most desirable characteristics of silicone rubber is that when burned it produces an ash. This ash, held in place with fiber glass braids, will continue to be an insulator. Radiation resistance is superior to other alternative high temperature materials lying within the range of 5×10^7 to 1×10^8 roentgens. See section 3-11.

Silk—used very little today as yarn serving and braid. See section 3-3.

Varnished Cloth—tape wraps of varnished cambric for insulation of wires and cable offer properties that lie between those of rubber and impregnated paper. This applies to dielectric strength, flexibility, resistance to moisture and heat, and handling cable connections and terminations. It provides a greater measure of moisture resistance than paper. In dry locations, it may be used without a lead sheath. It can be used for low and moderate voltage cables. See section 3-7.

Vinylidene fluoride—this thermoplastic resin, a fluorocarbon, is characterized by very good mechanical, electrical, and chemical properties. In primary insulation and in jackets for multi-conductor cables, it has performed successfully at temperatures from —80° to 300°F. The material can be easily extruded, or applied as a film, or solution or dispersion coating. PVF_2 offers excellent resistance to abrasion and cut-through. Radiation crosslinking provides improved heat resistance. Applications include hook-up, control, aircraft, lead, and computer wires and cables. See section 3-10.

Acknowledgment

The editors are indebted to the following individuals who have reviewed, made suggestions, or contributed information for improving this section: Lillian Nygren, Wire and Cable Dept., General Electric Co., Bridgeport, Conn.; R. M. Akin, III, Hudson Wire Co., Ossining, N.Y.; Dr. R. B. Blodgett, The Okonite Co., Passaic, N.J.; H. D. Gudrian, Union Carbide Corp., Plastics Div., New York City; M. C. Cheney, The Lewis Engineering Co., Naugatuck, Conn.; B. J. Burkett and C. H. Weber, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.; E. J. Merrell, Phelps Dodge Copper Products Corp., Yonkers, N.Y.; W. H. Guthrie, Phillips Petroleum Co., Bartlesville, Okla.; R. S. Kelly, International Wire Products Corp., Midland Park, N.J.; and Walter Koval, Gary R. Squires, D. Binch, and F. T. Clark, Haveg Industries, Inc., Wilmington, Del., and Winooski, Vt. (Super Temp Wire Div.).

SUPPLIER DIRECTORY LISTING

NOTE: Numbers in parentheses following each product covered in this section correspond with the numbers shown in front of each supplier of products listed here (thus indicating which firms supply the product concerned). Only company names are listed here — see Part 4, section 4-1, for addresses of suppliers. Bold face type indicates advertisers — see advertisers' listing at back of book for page numbers of advertisements.

Products Covered in this Section

Listed According to Insulation and Jacketing Materials Used on Wire

Acrylic (7, 29, 55)
Anodic films (62)
Asbestos (3, 7, 9, 13, 16, 19, 31, 41, 47, 53, 68, 77, 81, 86, 90)
Butyl rubber (2, 7, 9, 10, 11, 13, 18, 25, 29, 30, 31, 32, 33, 41, 46, 53, 59, 73, 77, 81, 90)
Cellular or foamed dielectric (2, 4, 9, 11, 15, 19, 21, 31, 50, 51, 52, 63, 77, 79, 83, 88)
Celluiose acetate (9, 19, 29, 36, 51, 63)
Ceramic (1, 5, 24, 28, 35, 43, 57, 62, 65, 94, 96)
Chlorosulfonated polyethylene (9, 13, 18, 25, 29, 31, 32, 51, 55, 63)
Cotton (7, 9, 11, 16, 18, 19, 21, 23, 25, 29, 36, 47, 50, 55, 64, 65, 88, 92)
Ethylene propylene rubber (4, 9, 11, 13, 18, 25, 29, 30, 31, 41, 46, 59, 73)
Ethylene vinyl acetate (9, 16, 21, 29, 31, 51, 54)
Fluoroelastomers (9, 29, 51, 54, 72, 92)
Fluorinated ethylene propylene (4, 6, 9, 11, 13, 18, 19, 25, 29, 34, 38, 40, 51, 52, 63, 64, 76, 80, 81, 86, 87, 95)
Gas filled (7, 29, 59)
Glass fiber (3, 6, 7, 9, 10, 11, 15, 18, 19, 21, 23, 25, 29, 31, 34, 36, 38, 39, 50, 51, 58, 64, 65, 81, 82, 86, 91, 92)
Ionomers (29, 51)
Mica (13, 17, 19, 30, 84, 86)
Mineral (magnesium oxide) insulated (29, 67)
Natural rubber (4, 7, 9, 25, 29, 32, 46, 59, 77, 79)
Neoprene (2, 4, 7, 9, 11, 13, 18, 25, 29, 31, 32, 33, 41, 46, 53, 59, 70, 73, 76, 77, 79, 81, 90, 92)
Nitrile butadiene (NBR) (9, 25, 29, 46, 73, 79, 81)
Nitrile butadiene/polyvinyl chloride blend (9, 16, 25, 29, 31, 51, 73)
Nylon (3, 4, 7, 8, 9, 11, 13, 15, 18, 19, 21, 23, 25, 29, 31, 32, 33, 36, 41, 45, 46, 47, 50, 51, 52, 54, 55, 63, 64, 76, 77, 78, 79, 81, 88, 90)
Oil filled (29, 59, 70)
Paper (7, 16, 25, 29, 30, 49, 50, 70, 77)
Polyamide fiber (4, 9, 16, 21, 25, 29, 36, 51, 78, 81, 86, 9)
Polyester fiber (4, 9, 10, 16, 25, 29, 51, 9, 36, 92)
Polyester film (4, 7, 9, 11, 13, 16, 25, 29, 32, 47, 49, 51, 54, 78, 79, 81, 86, 95)
Polyethylene (2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 15, 16, 18, 19, 21, 23, 25, 29, 31, 33, 36, 40, 41, 45, 46, 50, 51, 52, 54, 59, 63, 64, 73, 76, 77, 78, 79, 81, 83, 88, 89, 90)
Polyethylene, chemically cross-linked (2, 7, 9, 13, 18, 19, 21, 25, 29, 31, 32, 33, 41, 46, 59, 77)
Polyethylene, irradiated (3, 29, 33, 41, 51, 63, 69, 95)
Polyethylene butadiene (18, 25, 29, 77)
Polyimide film (4, 13, 15, 16, 21, 25, 29, 34, 38, 39, 48, 55, 64, 65, 75, 76, 86, 88, 95)

Polyimide enamel over FEP or TFE (11, 25, 29, 34, 38, 43, 64, 76, 81, 87)
Polyphenylene oxide (29, 51)
Polypropylene (4, 8, 9, 15, 18, 19, 21, 25, 29, 31, 36, 46, 51, 52, 63, 76, 77, 79, 81, 88)
Polysulfone (4, 19, 21, 25, 34, 51, 63, 76)
Polytetrafluoroethylene (9, 10, 11, 13, 14, 18, 19, 20, 25, 27, 29, 33, 34, 39, 48, 51, 52, 63, 64, 73, 76, 77, 79, 80, 81, 86, 87, 88, 91, 92, 95)
Polytrifluorochloroethylene (9, 10, 18, 25, 29, 33, 34, 38, 72, 88)
Polyurethane rubber (4, 7, 9, 19, 29, 33, 47, 51, 73, 79, 81)
Polyvinyl chloride (2, 3, 4, 6, 8, 9, 10, 11, 13, 16, 18, 19, 20, 21, 25, 29, 31, 32, 33, 36, 38, 41, 45, 46, 50, 51, 52, 53, 54, 56, 59, 63, 64, 71, 73, 76, 77, 78, 79, 80, 81, 82, 83, 86, 87, 88, 90, 92)
Polyvinylidene fluoride (3, 4, 20, 25, 29, 31, 33, 34, 51, 86)
Polyvinylidene fluoride, cross-linked (3, 29, 33, 69)
Rayon (4, 9, 17, 18, 21, 29, 41, 46, 50, 51, 92)
Silica fibers (9, 34, 51, 65)
Silicone rubber (6, 7, 9, 10, 13, 16, 18, 19, 25, 29, 30, 31, 32, 33, 41, 44, 46, 51, 59, 72, 73, 77, 78, 79, 81, 82, 90, 92)
Silk (4, 9, 23, 47, 55)
Styrene-butadiene (SBR) (9, 13, 31, 46, 77, 90)
Varnished cloth (7, 13, 29, 30, 31, 59, 70, 77)

Listed According to Application, Function, Type, or Form of Wire

Aerial (2, 3, 6, 7, 9, 11, 13, 15, 16, 18, 19, 20, 22, 29, 31, 36, 41, 44, 45, 46, 48, 51, 59, 65, 76, 77, 81, 86, 90)
Aircraft and missile (3, 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 29, 31, 34, 36, 38, 40, 41, 43, 45, 46, 48, 50, 51, 52, 54, 55, 63, 64, 65, 66, 69, 73, 75, 76, 77, 78, 79, 80, 81, 86, 88, 92, 93, 94, 95, 96)
Alloy (not insulated) (23, 24, 37, 42, 46, 47, 55, 78)
Apparatus (3, 4, 9, 11, 13, 15, 16, 18, 19, 20, 21, 22, 29, 31, 34, 48, 51, 54, 55, 59, 63, 64, 69, 76, 80, 81, 86, 90, 95, 96)
Appliance (3, 4, 7, 9, 10, 11, 13, 15, 16, 18, 19, 20, 21, 23, 24, 25, 29, 31, 32, 34, 36, 41, 47, 51, 53, 54, 55, 63, 64, 69, 76, 77, 78, 81, 86, 88, 90, 96)
Armored (3, 7, 13, 15, 16, 18, 19, 23, 29, 31, 40, 41, 46, 51, 59, 63, 77, 79, 83, 86)
Automotive (3, 4, 6, 7, 9, 10, 13, 15, 16, 17, 18, 21, 23, 25, 32, 41, 45, 46, 47, 50, 51, 55, 63, 74, 75, 76, 96)
Balloon insulated (19, 29, 83)
Bare (not insulated) (7, 10, 12, 16, 18, 23, 25, 29, 37, 42, 46, 47, 55, 67, 81)
Building (2, 7, 15, 16, 18, 21, 29, 45, 46, 63, 70, 77)
Cable terminations (1, 4, 14, 20, 22, 30, 32, 33, 38, 44, 61, 65, 66, 69, 79)
Clad (not insulated) (3, 16, 20, 29, 37, 84)
Coaxial (2, 3, 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 16, 18, 19, 20, 21, 29, 31, 34, 36, 39, 40, 41, 43, 45, 46, 50, 51, 52, 60, 63, 64, 69, 76, 77, 78, 79, 81, 83, 85, 86, 88, 89, 92, 95)
Coiled (3, 4, 7, 9, 10, 16, 20, 23, 29, 41, 47, 79)
Communication (3, 4, 6, 7, 8, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 29, 31, 33, 34, 36, 38, 40, 41, 43, 45, 46, 48, 50, 51, 54, 59, 63, 64, 65, 69, 71, 76, 77, 78, 79, 81, 83, 86, 88, 92, 93, 95)
Control (2, 3, 4, 7, 8, 9, 10, 11, 13, 15, 16, 18, 19, 20, 21, 22, 23, 29, 31, 33, 34, 36, 38, 40, 41, 45, 46, 48, 50, 51, 53, 54, 55, 59, 63, 64, 65, 69, 70, 71, 76, 77, 78, 79, 80, 81, 83, 86, 88, 90, 92)
Cord sets (3, 7, 9, 10, 16, 20, 29, 33, 41, 46, 53, 60, 63, 78, 90)
Delay (40, 51, 52, 55, 76)
Direct burial (2, 3, 5, 7, 8, 9, 11, 13, 15, 16, 18, 19, 21, 29, 31, 40, 41, 45, 46, 50, 59, 63, 70, 77, 79, 83, 90, 95)
Electronic (3, 4, 6, 7, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 29, 31, 33, 34, 36, 45, 46, 48, 51, 54, 55, 63, 64, 69, 71, 73, 76, 77, 78, 79, 80, 81, 83, 86, 89, 91, 92, 95, 96)
Fixture (4, 7, 10, 11, 13, 15, 16, 18, 19, 21, 23, 25, 29, 31, 36, 41, 45, 51, 63, 64, 69, 77, 78, 81, 86, 88, 90, 96)
Harnesses and assemblies (4, 9, 13, 16, 20, 22, 26, 29, 32, 33, 36, 38, 40, 44, 45, 48, 60, 63, 65, 66, 67, 69, 73, 76, 78, 79, 80, 81, 92, 93, 95)
Heating (5, 7, 13, 17, 19, 21, 23, 25, 29, 31, 45, 47, 55, 64, 67, 76, 77, 78, 86, 88)
High temperature (3, 5, 6, 7, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 29, 31, 34, 36, 40, 41, 44, 45, 47, 51, 55, 59, 63, 64, 65, 67, 69, 73, 76, 77, 78, 79, 81, 86, 88, 90, 91, 92, 94, 95, 96)
High voltage (2, 3, 6, 7, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 25, 29, 31, 32, 33, 36, 39, 40, 43, 44, 45, 46, 50, 51, 59, 63, 64, 65, 70, 73, 77, 78, 79, 81, 86, 90, 95)
Hook-up (2, 3, 4, 6, 7, 9, 10, 11, 13, 15, 16, 18, 20, 21, 23, 25, 29, 31, 34, 36, 38, 39, 41, 44, 45, 50, 51, 52, 53, 54, 63, 64, 69, 71, 76, 77, 78, 79, 80, 81, 82, 86, 88, 91, 92, 95)
Ignition (3, 7, 9, 10, 13, 15, 16, 18, 23, 25, 29, 32, 41, 45, 47, 81, 95)
Laminated (7, 22, 31, 38, 54, 59, 79, 80, 95)
Lead covered (2, 7, 13, 18, 29, 31, 46, 59, 70, 77)
Lighting (2, 7, 13, 16, 18, 19, 23, 25, 29, 31, 36, 45, 46, 59, 63, 76, 77, 81)
Line (7, 15, 16, 18, 20, 29, 46, 63, 77, 81)
Machine tool (2, 3, 4, 7, 10, 11, 15, 16, 18, 21, 25, 29, 31, 36, 41, 45, 46, 48, 51, 53, 59, 63, 64, 77, 78, 88)
Mining (2, 3, 7, 11, 13, 14, 15, 16, 18, 21, 29, 31, 41, 46, 59, 63, 64, 70, 77, 90)
Motor lead (7, 9, 11, 13, 15, 16, 18, 19, 21, 25, 29, 31, 34, 36, 41, 46, 51, 59, 63, 64, 76, 77, 78, 81, 86, 90)
Multi-conductor (2, 3, 4, 5, 6, 7, 9, 10, 13, 14, 15, 16, 18, 19, 20, 21, 22, 25, 29, 31, 32, 33, 34, 36, 38, 39, 40, 41, 45, 46, 48, 50, 51, 52, 53, 54, 59, 60, 63, 64, 65, 69, 70, 71, 73, 76, 77, 78, 79, 80, 81, 83, 86, 90, 91, 92, 95)
Plated or coated (not insulated) (6, 12, 16, 18, 25, 29, 37, 40, 42, 55, 81, 84)
Power (2, 3, 6, 7, 10, 13, 15, 16, 18, 20, 21, 25, 29, 31, 33, 38, 41, 45, 46, 59, 70, 76, 77, 79, 81, 83, 86, 90)
Radio and television (2, 3, 4, 6, 7, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21, 23, 25, 29, 31, 34, 36, 38, 40, 45, 50, 51, 52, 54, 60, 63, 64, 69, 71, 76, 78, 79, 81, 86, 92, 94, 96)
Resistance (3, 4, 5, 7, 10, 13, 16, 17, 19, 23, 24, 25, 31, 32, 37, 38, 47, 51, 55, 64, 76, 78, 86)
Ribbon (flat) (3, 4, 11, 22, 23, 29, 32, 34, 36, 38, 46, 48, 54, 63, 69, 76, 77, 80, 84, 95)
Service (2, 7, 10, 15, 16, 18, 20, 29, 31, 46, 63, 70, 77)
Service entrance (2, 7, 16, 18, 29, 31, 36, 63, 70, 77)
Shielded (3, 4, 6, 7, 9, 10, 11, 13, 15, 16, 18, 19, 20, 21, 22, 24, 25, 29, 31, 34, 36, 38, 40, 45, 46, 50, 51, 52, 56, 59, 64, 65, 69, 70, 73, 76, 77, 79, 81, 86, 88, 90, 91, 92, 93, 95)
Shipboard (3, 7, 10, 13, 14, 15, 16, 18, 19, 21, 22, 29, 31, 33, 34, 40, 45, 51, 59, 63, 64, 69, 73, 76, 77, 79)
Signal (2, 3, 4, 5, 7, 10, 11, 13, 15, 16, 18, 19, 20, 21, 22, 23, 25, 29, 31, 34, 38, 40, 45, 46, 48, 51, 59, 63, 64, 73, 76, 77, 79, 81, 83, 86, 90, 95)
Submarine (6, 7, 14, 15, 16, 22, 23, 29, 31, 33, 38, 40, 45, 51, 59, 63, 64, 69, 73, 77, 79, 83, 95)
Switchboard (3, 4, 7, 9, 11, 13, 15, 16, 18, 19, 21, 29, 31, 38, 40, 45, 50, 51, 63, 64, 77, 83, 88)
Telephone (3, 4, 6, 7, 8, 9, 10, 11, 16, 18, 21, 23, 29, 36, 38, 41, 45, 46, 50, 54, 59, 63, 77, 81, 83, 88)
Thermocouple (4, 5, 13, 16, 19, 23, 25, 31, 34, 39, 41, 45, 47, 51, 56, 65, 67, 69, 76, 77, 81, 96)
Tinsel (not insulated) (16, 29, 37)
Underground (2, 3, 7, 13, 14, 15, 16, 18, 29, 30, 31, 33, 45, 46, 59, 70, 77, 83, 90)

Suppliers of Preceding Products

1—Advac Products, Inc., Subsidiary of GTI Corp.
2—Alcoa, Rome Cable Div.
3—Alpha Wire
4—Amerace Corp., Gavitt Wire & Cable Co. Div.
5—American-Standard, Aero Research Instrument Dept.
6—Amphenol Corp., Amphenol Cable Div.
7—**ANACONDA WIRE AND CABLE CO.**
8—Ansonia Wire & Cable Co.
9—**BELDEN MANUFACTURING CO.**
10—Birnbach Radio Co., Inc.
11—**BRAND-REX DIV., AMERICAN ENKA CORP.**
12—Camden Wire Co., Inc.
13—Cerro Corp., Rockbestos Wire & Cable Co. Div.
14—Chemplast Inc.
15—Chester Cable Corp., Subsidiary of Tennessee Corp.
16—Coleman Cable & Wire Co.
17—Columbia Technical Corp., Industrial Mica Div.
18—Continental Copper & Steel Industries Hatfield Wire & Cable Div.
19—Continental Wire Corp.
20—Daburn Electronics & Cable Corp.
21—Dielectric Materials Co.
22—Digital Sensors, Inc.
23—Driver-Harris Co.
24—Duramic Products Inc., Kawecki Chemical Co. Div.
25—Eltra Corp., The Prestolite Co. Prestolite Wire & Cable
26—Electrovert Inc., Electro-Mechanical Div. and Components Equipment Div.
27—Enfo Corp.
28—Frenchtown Porcelain Co.
29—**GENERAL CABLE CORP.**
30—General Electric Co., Insulating Materials Dept.
31—**General Electric Co., Wire & Cable Dept.**
32—General Motors Corp., Packard Electric Div.
33—General Relay Corp., General Reliance Div.
34—Haveg Industries, Inc., Haveg/Super Temp Wire Div.
35—**HEANY INDUSTRIAL CERAMIC CORP.**
36—Holyoke Wire and Cable Corp.
37—**HUDSON WIRE CO.**
38—Hughes Aircraft Co., Applied Techniques Dept., C & M Lab.
39—Insc Electronic Products, Inc.
40—International Silver Co., Times Wire & Cable Div.
41—International Telephone & Telegraph Corp., ITT Wire & Cable Div.
42—**INTERNATIONAL WIRE PRODUCTS CORP.**
43—Isolantite Manufacturing Corp.
44—Ja-Bar Silicone Corp.
45—Judd Wire Manufacturing Corp.
46—Kaiser Aluminum & Chemical Sales Inc., Electrical Products Div.
47—The Kanthal Corp.
48—Kent Corp., ACI Div.
49—Krafelt Co.
50—Lenz Electric Manufacturing Co.
51—L. Frank Marzel & Sons
52—Microdot Inc., Connector/Cable Products Div.
53—Miller Electric Co.
54—3M CO.
55—Molecu Wire Corp., Subsidiary of Superior Tube Co.
56—Samuel Moore & Co., DeKoron/Synflex Div.
57—National Beryllia Corp.
58—New Plastic Corp., Nuple Manufacturing Co. Div.
59—The Okonite Co., Subsidiary of Ling-Temco-Vought, Inc.
60—Paraplegics Manufacturing Co., Inc.

61—Permali, Inc.
62—Permaluster, Inc.
63—Phalo Corp., Transitron Electronic Corp. Div.
64—Philadelphia Insulated Wire Co.
65—Physical Sciences Corp.
66—The Pyle-National Co., Connector Div.
67—Pyrometer Co. of America, Inc.
68—**RAYBESTOS-MANHATTAN, INC., ASBESTOS TEXTILE DIV.**
69—Raychem Corp.
70—**REYNOLDS METALS CO.**
71—Rockland Insulated Wire & Cable Co., Inc.
72—Ronthor Reiss Corp., Synthetic Products Div.
73—Rutherford Research Products Co.
74—St. Marys Carbon Co.
75—G. T. Schjeldahl Co., Electrical Products Div.
76—Simplex Wire & Cable Co., Hitemp Wires Div.
77—Simplex Wire & Cable Co., Power and Control Div.
78—The Singer Co., Wirekraft, Climate Control Div.
79—South Bay Cable Corp.
80—Spectra-Strip Corp.
81—Standard Wire and Cable Co.
82—SUFLEX CORP.
83—Superior Cable Corp.
84—Sylvania Electric Products Inc., Parts Div.
85—Temflex Corp.
86—Temp-Flex Insulated Wire Co., Inc., Subsidiary of Carlisle Corp.
87—Thermal Wire of America, Inc.
88—Thermatics Inc.
89—United-Carr Inc., Cinch Manufacturing Co. Div.
90—Western Insulated Wire Co.
91—Wirecraft Products Inc.
92—Wireonics Products Co.
93—The Zippertubing Co.
94—Zirconium Corporation of America
95—W. L. GORE & ASSOCIATES, INC.
96—Maryland Lava Co., Inc.