

IEEE 1242

Guide for Specifying and Selecting Cable for Petrochemical Plants

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THE PURPOSE OF THIS ARTICLE is to provide an overview of IEEE 1242-1999, *Guide for Specifying and Selecting Power, Control, and Special Purpose Cable for Petroleum and Chemical Plants*.

This standard addresses wire and cable design, materials, testing, and installation, along with illustrations of typical constructions and application criteria. An extensive cross-referenced list of standards and technical papers, as they apply to the wire and cable industry, is included in the appendix of the standard.

Background

A paper titled "Wire and Cable Update-1990" [1] was presented at the 1990 Petroleum and Chemical Industry Committee (PCIC) Conference in Houston, Texas, USA. During the writing of the paper, the authors concluded that the information it contained could possibly form the basis of a PCIC Working Group (WG) to address the specification and selection of cable in the petrochemical industry. Since the authors were members of both the IAS/PCIC and the PES/Insulated Conductors Committee (ICC), there would be a possibility of getting input not only from the user commu-

What's in it, and HOW will it help you?

nity, but also from the manufacturing and consulting communities. Therefore, a joint WG between PCIC and ICC was formed, and work proceeded on the guide.

The final draft from the WG was submitted to IEEE for balloting in February 1998. After the resolution of negatives and coordinating society comments, a new draft was balloted and the IEEE Standards Activities Board approved the guide in June 1999.

The guide contains useful information on the specification and selection of power, control, and special-purpose cable typically used in petroleum, chemical, and similar type plants. It addresses those topics that are peculiar to the petrochemical industry. However, it includes many re-

cent developments, such as strand filling; low-smoke, zero-halogen materials; water swellable tapes; chemical-moisture barriers; and cable testing. This guide is intended to help the user in developing specifications for cable constructions by addressing industry standards in conjunction with those problems peculiar to the petrochemical industry.

The guide provides the user with pertinent information on cable designs, applications, and the latest test procedures. It is intended to be an informational tool for the new, as well as the more seasoned, engineer. In this capacity, it contains an extensive ref-



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erence and cross-reference listing of cable standards, including those from the United States, Canada, and some from Europe. Illustrations and tables are provided with a correlation to applicable industry standards for cable constructions. Application guidelines are provided for the type of installations found in the petrochemical industry as they relate to electrical, mechanical, physical, thermal, and environmental properties of the cable. The use of this guide should help to eliminate premature cable failures due to improper cable specification, selection, and application.

The following major headings in this article bear the same title as the applicable major clauses contained in the guide. Under these headings is a summary of content that should be of benefit to those evaluating the scope and need for this publication. The applicable clause number from the guide is shown, in parenthesis, after the heading.

Typical Constructions (Clause 3)

This clause provides detailed information on various low- and medium-voltage cable constructions that are typically used in petroleum and chemical plants. There are 19 figures that provide photographic illustrations along with text, giving specifics of the cable components, applicable standards, conductor temperature range, flame ratings, and applications. Fig. 1 is a typical example of these illustrations.

Application Guidelines (Clause 4)

This clause provides an overview of the many factors to be considered in selecting a cabling system for a petroleum or chemical plant. Additional details on many of these matters are addressed in subsequent clauses.

THE GUIDE PROVIDES THE USER WITH PERTINENT INFORMATION ON CABLE DESIGNS, APPLICATIONS, AND THE LATEST TEST PROCEDURES.

Types of Installations

The size and electrical load for the facility, the geographic layout, environmental aspects, and the electrical service supply are among the first considerations. Decisions on these matters are made early in the engineering program. After project criteria is determined, a decision on the type of cable installation, whether underground or overhead, can be made. Each system has its merits. The trend seems to be more toward tray systems (Fig. 2), although underground systems are often selected where severe weather, fire hazard, or environmental conditions present a hazard to overhead systems.


Underground cabling systems are normally either direct buried (Fig. 3) or installed in ducts (Fig. 4). Either type provides protection from wind, explosions, fire, or accidental contact from cranes or other construction equipment. However, exposure to ground water and chemical contamination may warrant cable

designs that provide protection from such deleterious elements, as well as additional mechanical protection in the case of direct buried cables.

Overhead, supported cabling systems are initially less costly and easier to maintain, modify, or replace. A typical example of an overhead messenger supported cable system is shown in Fig. 5.

Electrical Considerations

Resistance to voltage breakdown, due to peak transient voltages, of any electrical distribution system is a function of its design basic impulse level (BIL) of equipment and its connecting cabling plus the thermal aging characteristic of the cable. The insulation of the cable selected, and its thickness, must be compatible with the rated operating



Construction:
 A - Conductor: Copper, bare, soft, Class B, concentric stranded per ASTM B-8 (Alum available)
 B - Strand Screen: Extruded thermoset semi-conducting EPR or polyolefin
 C - Insulation: EPR, XLPE or TRXLPE
 D - Insulation screen: Extruded semi-conducting EPR or polyolefin
 E - Shield: Helically applied overlapped copper tape or helical wire shield
 F - Jacket: PVC or CPE (Thermoplastic), CSPE, CPE (Thermoset) or LSZH

Applicable Standards: AEIC CS-8, ICEA S-93-639/NEMA SC74, ICEA S-97-682, UL 1072, CAN/CSA C68.3

Conductor Temperature: 90 °C wet or dry, 105 °C available in EPR

Flame Rating: Normally capable of passing vertical flame test per UL1581 or IEEE 1202. Must be approved for CT use if installed in tray per UL 1072 option.

Applications: Raceways, ducts, direct burial, messenger and tray subject to NEC and CSA restrictions.

Remarks: Requires Stress cone terminations. Give tree retardancy consideration when selecting insulation for underground applications

5-35 kV, Type MV-90, 1/C, helical tape or wire shield.

voltage of the system, as well as the BIL level of the source and utilization end equipment.

Ampacity determination includes consideration of many factors that are listed in the guide. Normally, National Electrical Code (NEC) tables are most often used. However, under proper engineering supervision, ampacity may be determined by use of the Neher-McGrath method. References to these methods are provided.

Methods for selecting grounding conductors for neutral, system, and equipment are included in this clause, as well as fault current ratings of conductors and metallic shields.



Cable tray system.



Underground direct buried system.



Underground duct system.

Mechanical and Physical Considerations

The sheaths or coverings used over other cable materials to protect the cable components from environmental and installation conditions can greatly affect the overall life cycle economics of the cable system. Both metallic and nonmetallic materials, or a combination of these coverings, are available to provide the protection needed for specific conditions. Some of these specific conditions include the effect of rodents, insects, abrasion, impact, moisture, acids, alkalis, and other chemicals. The sheaths or coverings may be applied as protection over single conductors or over multiple conductors. Different types of coverings and sheaths are outlined in the guide with references containing further information.

Environmental Considerations

The effect of the cable on its surroundings must be considered in response to the increased awareness of environmental issues. The potential for arc flash, explosion, fire propagation, smoke, and the emission of toxic and/or corrosive gases must be considered in the application and location of the cable. Also, the effect of the environment on the cable must be considered. Specific topics covered include hazardous areas, fire safety considerations, flame spread, smoke measurement, corrosivity, toxicity, and cold temperature installation.

Conductors (Clause 5)

This clause reviews conductor materials and stranding. The two most common conductor materials used are copper and aluminum. The NEC requires conductors to be stranded for sizes 8 AWG and larger. Stranded conductors are typically made more flexible by increasing the number of wires in the conductor. The size specified for the conductor in AWG, kcmil, or mm² denotes the total area of the conductor metal. Factors to consider in selecting copper or aluminum conductors are addressed, along with information on tinned or lead alloy-coated copper and filled-strand conductors.

Insulation (Clause 6)

Materials and Thickness Available, Low Voltage (0-2,000 V)

The most readily available insulations for low-voltage cables are polyvinyl chloride (PVC), crosslinked polyethylene (XLPE), and ethylene propylene rubber (EP, EPR, or EPDM). Chlorosulphonated polyethylene (CSPE), chlorinated polyethylene (CPE), and polyamide (Nylon) are sometimes used for the second layer insulation/jacket in dual-layer extrusions for mechanical protection. The temperature rating of such materials is usually 75 °C for thermoplastic materials and 90 °C for thermoset materials.

The insulation type and insulation thickness of wire and cable used in petrochemical plant applications are usually set by industry standards written by Underwriters Laboratory (UL), the Canadian Electrical Code (CSA), or the National Electrical Manufacturers Association (NEMA)/Insulated Cable Engineers Association (ICEA). In the United States, virtually all wire and cable used in petrochemical plants are required to be installed in compliance with the NEC (see NFPA 70-2002). In Canada, wire and cable must be installed in compliance with CSA

C22.1. What this means, in a practical sense, is that the wire or cable must bear the proper UL or CSA marking for the application. It must also be installed in a manner consistent with the code requirements applicable to the particular facility in which the wire or cable is being used.

Tables are included in Clause 6 to provide insulation thickness data for both single- and multiconductor low-voltage cables of various constructions.

Materials and Thickness Available, Medium Voltage (5-35 kV)

Insulation types and thicknesses for MV cables are established by UL, CSA, NEMA/ICEA, and the Association of Edison Illuminating Companies (AEIC) standards. The most predominate insulation materials are XLPE, tree retardant crosslinked polyethylene (TRXLPE), and EP, EPR, or EPDM. However, low- and medium-density polyethylene can be used for some applications.

The cable insulation level required for an MV application depends on the neutral grounding type (e.g., solidly or impedance grounded) and the intended mode of plant operation (e.g., maximum equipment protection with fast tripping or minimum process interruption with time-delayed tripping). Insulation levels of 100, 133, and 173% are defined in Clause 4. On critical circuits where maximum reliability is required, the use of thicker insulation is recommended.

Tables are included that list insulation thicknesses for some of the more common shielded MV cable constructions, along with the applicable industry standards. Insulation thicknesses for nonshielded MV cable, other voltage ratings, and conductor sizes larger than 506.7 mm^2 (1,000 kcmil) can also be found in the standards referenced. A cross-section of a typical MV shielded cable is shown in Fig. 6.

Performance Requirements

Insulating materials have improved over the years and now provide the specifying engineer with a wide range of properties that enable an optimum match to a particular application. The choice of insulation will depend on many factors, such as the operating voltage and temperature, the type (signal or power) and frequency of electric energy to be transmitted by the conductor, the type of outer protective covering for the insulation, the amount of flexibility desired, outside chemical influences, etc. Where a number of insulation materials are deemed suitable for an application, selection may be made based on economics, maintenance, or other factors. In any case, it is important to consider the minimum acceptable performance characteristics of an insulation to assure the long-term reliability of an electrical system. The following properties should be considered in evaluating insulating materials:

- dielectric strength
- capacitance
- thermal characteristics and heat dissipation
- power factor (dissipation factor), insulation resistance, and losses
- resistance to water treeing
- physical properties, chemical resistance, and environmental considerations.

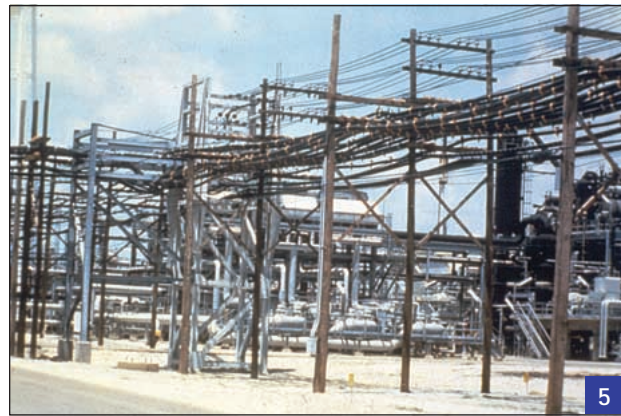
The choice of materials for the cable design will depend on the degree of abuse it is subjected to, or the environment in which it is being designed to operate. However, the overriding choice of a specific material will depend on its dielectric properties or degree of reliability required.

Shielding (Clause 7)

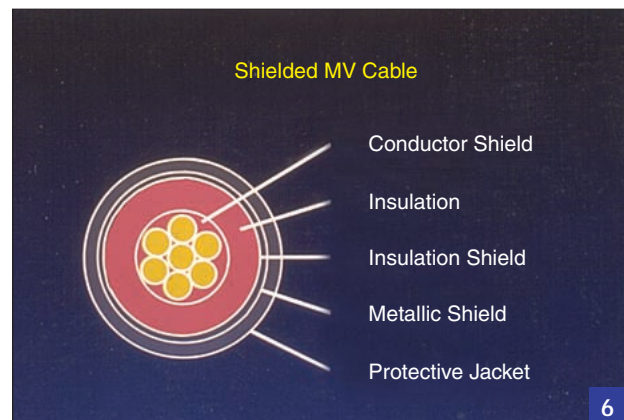
Many low-voltage cables and most MV cables, as well as certain special-purpose cables, require some form of electrical shielding. Clause 7 provides the user with many details on shielding selection and application. Some system characteristics that should be considered in determining the need for shielding are the functioning of overcurrent devices, required levels of fault or surge current, the manner in which the system may be grounded, desired levels of electrostatic protection, and environmental factors, such as incidence of lightning. It is recommended that cables operating at 4-kV and above be shielded.

Environmental Considerations

There are environmental considerations that are important to overall cable operation and may have an affect directly or indirectly on the shielding. One of the key considerations is ambient temperature and its affect on current-carrying capacity. A second is location, i.e., indoors, outdoors, or underground. All three locations have specific thermal characteristics that affect cable ampacity and potential shielding requirements. Specific



Overhead messenger supported system.



Typical MV shielded cable.

environmental considerations affecting shielding choices are corrosion and wet locations.

Electrical Considerations

There are several electrical system parameters to consider when using shielded cable. Among these are the following:

- fault currents
- voltage considerations
- splicing devices and techniques
- grounding of shields
- shield losses
- insulating barriers in the shield.

Semiconducting Materials

These materials are used in MV cable to form a conductive bridge from either the conductor to the inside surface of the insulation or from the outer surface of the insulation to the metallic shield. The function is to prevent voids and ensure an even distribution of the electrical stress. The formulation of semiconductive materials require the use of large amounts of conductive carbon black, which is usually dispersed in a suitable polyolefin, EP, or butyl acetate compound. In addition to the principal constituents, minor amounts of proprietary additives are included to aid dispersion, heat stability, and adhesion to the insulation. The properties of these materials vary depending on whether they are formulated for strand shielding or for insulation shielding.

Metallic Shielding Materials

Cable shields are nonmagnetic metallic materials. The two materials typically used for metallic shields are aluminum and copper. Aluminum requires a larger diameter as a wire or a thicker cross section as tape to carry the same current as copper. At equivalent current-carrying capacity, an aluminum shield will be lighter in weight but about 40% larger in dimensions. Aluminum shields are used for instrumentation, control, and communication cables, while copper shields are used with medium- and high-voltage cables.

The metallic shield needs to be electrically continuous over a cable length to adequately perform its functions of electrostatic protection, electromagnetic protection, and protection from transients, such as lightning and surge or fault currents.

A nonmetallic covering or jacket may be used over the shield for mechanical and corrosion protection. The covering must prevent exposure of the metallic shield during handling and installation. It is important to ensure that continuity of the metallic shield will not be broken during handling, installation, or operation.

Current Carrying Capability

The ability of a metallic shield or sheath to carry current is a function of its resistance. The lower the resistance, the more current it can handle at a given temperature.

THE USE OF THIS
GUIDE SHOULD
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Guidelines for the minimum amount of shield conductance required are given in ICEA standards.

It is necessary to consider the short circuit current (capacity) of the shield to assure the cable will not be damaged due to the heat generated during a fault.

Also to be considered is induced shield voltage. Circuits that employ shielded, single-conductor cable carrying alternating current will encounter a voltage buildup on the shield if the shield is grounded at only one point. The guide provides formulas for use in calculating the induced shield voltage for several cable arrangements.

Cable Jackets (Clause 8)

Cables in petrochemical plants are exposed to many different environments. Thus, the function of a jacket is to protect the underlying cable components from one or a number of exposures, including mechanical abuse, chemicals, flame, moisture, sunlight, and other radiation. Table 1 has been extracted from Clause 8 as an example. Basic properties of jackets used on cables in the petroleum and chemical industry are shown in this table.

The thickness of cable jackets depends primarily on the type of cable and the diameter of the core. In general, jacket thickness is specified in the applicable industry standards.

The following are the major electrical property considerations to be taken into account in selecting jacketing materials:

- **Dielectric Strength:** Cable jackets may be semiconducting or insulating. If insulating, a fair range of dielectric strengths are available.
- **Discharge and Tracking Resistance:** When a nonshielded cable rests upon or comes into contact with a ground plane, the ground plane acts as the outer plate of the capacitor, made up of the conductor, insulation and the ground plane. Discharges and tracking may cause erosion of the jacket material.

The physical properties of jackets is a major issue since protection from mechanical abuse during and after installation is the primary jacket function. Key considerations are toughness and flexibility.

A major consideration in selecting a jacket is whether a thermoplastic or thermosetting material is required. In most cases, a thermoplastic jacket is less expensive. However, thermoplastics will melt at some elevated temperature (different for each thermoplastic material) and, thus, could run or drip from the cable under extreme conditions. This may be unacceptable in many applications. Thermoset materials will not melt and run or drip at elevated temperatures.

Chemical, environmental, and flame properties must also be taken under consideration to include the following:

- **Chemical Resistance:** The resistance of jacket materials to various chemicals can be of major importance.

- **Moisture Resistance:** Moisture is a major consideration in all underground installations and many other plant locations. Thus, cable jackets and constructions that resist moisture should be considered for such applications.
- **Flame Resistance:** The relative degree to which a jacket material will burn is an important consideration in jacket selection. The importance is dependent on the application. The guide provides considerable information on this topic.
- **Smoke Density:** Obscured vision due to smoke generated by a fire can hinder escape and firefighting efforts. This can be a major consideration in work areas, control rooms, or where the public congregates. New and improved materials that have low or limited smoke emissions when burned are now available. Their use is growing rapidly.
- **Toxicity:** Many common materials emit toxic substances when burned. This can also reduce the escape potential of persons in the area of the fire. Low or zero halogen flame retardant compounds are available to address this problem.
- **Corrosivity:** Many materials emit corrosives when burned. This may be further complicated if the corrosives react with firefighting agents, such as water,

to form acids or bases. One such well-known reaction involves the combination of hydrogen chloride with water to form hydrochloric acid.

One other issue that must be considered is the future disposal of used cables. Some jacket compounds contain varying quantities of toxic materials, such as lead oxide, that may present future disposal problems from an environmental point of view.

Moisture and Chemical Protection (Clause 9)

There is a need for chemical and moisture protection for cables used in petrochemical plants, especially in underground applications. The environment in these plants can have an adverse effect on cable materials, potentially leading to less than expected performance. The various methods used to provide protection from the effects of chemicals and moisture are described in this clause. These methods are listed as follows:

- choice of jacketing materials
- use of chemical/moisture barrier (CMB) cables with laminate sheaths
- use of metallic sheaths as CMBs
- use of water blocking materials in cables.

When metallic shields and armors are used for moisture protection, suitable jackets over the shield are needed to

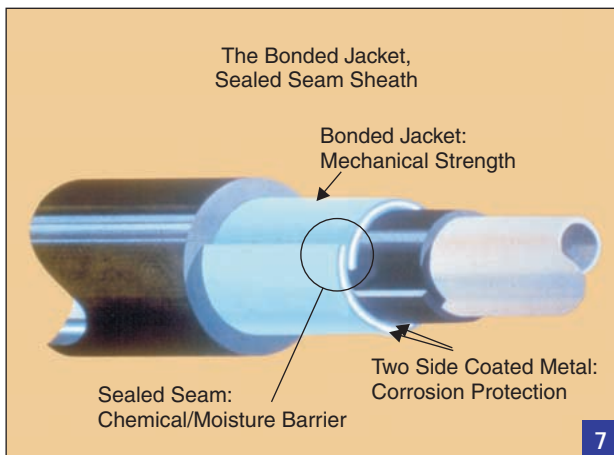
TABLE 1. PROPERTIES OF CABLE JACKETS

Properties	Thermoplastic			Thermoset	
	PE	PVC	CPE	CSPE/NEO	CPE
<i>Physical</i>					
Toughness	Excellent	Good	Excellent	Excellent	Excellent
Flexibility	Poor	Good	Good	Excellent	Excellent
Ease of installation	Good	Excellent	Excellent	Good	Good
<i>Thermal</i>					
Thermal rating, dry	75 °C	60-90 °C	60-90 °C	90 °C	90 °C
Thermal stability	Poor	Good	Good	Excellent	Excellent
Heat resistance	Good	Excellent	Excellent	Excellent	Excellent
<i>Chemical Resistance</i>					
Acids	Excellent	Excellent	Good	Excellent	Excellent
Alkalines	Excellent	Excellent	Good	Excellent	Excellent
Organic solvents	Excellent	Poor	Good	Good	Good
Oil	Poor	Fair-good	Fair-good	Good	Good
Water	Excellent	Good	Good	Good	Good
<i>Special Properties</i>					
Flame resistance	Poor	Good-excellent	Good-excellent	Excellent	Excellent
Weather resistance	Excellent	Good	Excellent	Excellent	Excellent
NOTE: These comparisons are general in nature. Specific formulations and compound variations of these materials will change the performance criteria to some extent.					

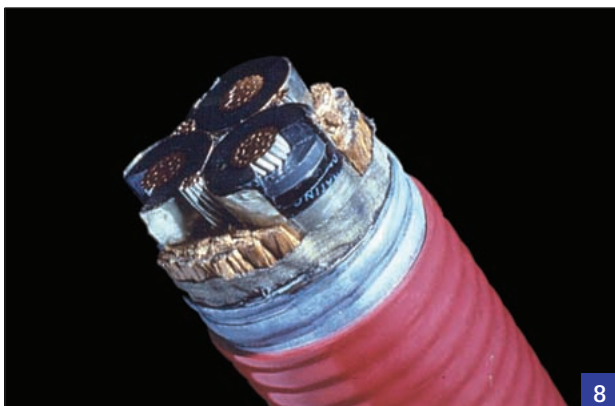
provide corrosion protection. Alternatively, protective coatings on the shielding materials and/or cathodic protection may be considered. Corrosion can generate pin holes and/or other openings in the metallic sheath. These openings will greatly compromise the chemical or moisture barrier.

The major topics covered in this clause and brief remarks on key points follow.

- **Moisture Resistance of Jackets:** No polymeric material can absolutely prevent the permeation of moisture. All have a defined moisture permeability that depends on the composition of the jacket and the materials that are used as additives or fillers to the jacket.
- **Chemical Resistance of Jackets:** The effects of chemicals and oils can cause hardening, softening, swelling, and/or cracking of polymeric jackets.
- **Laminate Sheaths:** Using such sheaths as chemical/moisture barriers is another option. The laminate sheath consists of a plastic-coated metallic tape bonded to the overall (outer) cable jacket, as shown in Fig. 7. The tape may be coated on one or both sides. The tape is longitudinally folded with an overlap at the edges. During the jacket extrusion process, the coating melts and bonds to the jacket, and the coatings in the overlap form a seal that resists moisture and chemical penetration. In addition to providing chemical and moisture protection, this type of sheath, with an aluminum substrate, is commonly used for instrument and low-voltage control cable to



Typical laminate sheath.



Typical metal-clad, Type TC cable.

provide electromagnetic interference (EMI) shielding and lightning protection. This type of sheath, using copper, has been used for underground applications of MV power cable to provide shielding as well as a CMB.

Extruded lead and aluminum sheaths can also be used as moisture or chemical barriers. Metallic sheaths with welded seams and lateral corrugations have likewise been used.

Water blocking is a means for preventing moisture migration. Methods to be considered are as follows:

- **Powders:** Swellable powders are used as longitudinal water blocks in cables to prevent longitudinal water penetration. These powders swell and expand sufficiently upon contact with water to form a gel-like material to block the flow of water.
- **Water-Blocking Tapes:** A water-blocking tape is usually a nonwoven synthetic textile tape impregnated with, or otherwise containing, a swellable powder.
- **Sealed Overlap:** To ensure a seal of the overlap, hot-melt adhesives can be used. These adhesives can be extruded or pumped into the overlap seam of a longitudinally formed metallic tape before the seam is closed during cable manufacture.

Metal Armors (Clause 10)

Metallic armored cables are used to provide additional mechanical protection, increase resistance to flame propagation, and provide a barrier to the intrusion of moisture and chemicals. The most common type of armored cable used in the petrochemical industry is a continuous corrugated aluminum, metal-clad (Type MC), cable, as shown in Fig. 8. The self-contained cable system of metal clad cable provides a “factory installed” system without subjecting the individual insulated conductors to the possible mechanical damage of installation, as they would be if pulled as single conductors into a conduit or cable tray.

Permitted uses, installation and construction specifications for Type MC cable are covered in Article 330 of the NEC. Canadian armored cables are manufactured and tested in accordance with CAN/CSA C22.2 No. 131. For UL label requirements, the constructions for 600- and 2,000-V cables are given in UL 1569. While MV types are covered by UL 1072. Typical requirements for sheaths, interlocked armor, flat tape armor, and round wire armoring, including required bedding and covering, appear in specifications such as ICEA S-93-639 (NEMA WC 74). Metal-clad cables, for use in Class 1, Division 1 hazardous areas, have increased mechanical properties and specific grounding requirements, as set forth in UL 2225 and CAN/CSA C22.2 No. 131. UL identifies such cables as Type MC-HL.

The various types of metal armors, including the key features for each type of armor, are listed in the tables of Clause 10. Descriptions, materials and applications are also covered.

Cable Quality and Testing (Clause 11)

Historically, general design parameters for wire and cable were developed by cable manufacturers and users. Currently, readily available specifications based upon industry and national standards provide design parameters and quality requirements. Comprehensive designs, utilizing

strand filling, super smooth semiconducting screens, extra clean insulation, swellable moisture sealing materials, and metal/plastic laminate shielding and sheathing, are extending cable life.

Quality assurance principles used in the wire and cable industry provide a basis for evaluating acceptable electrical, chemical, and physical properties for these products. As a result, quality assurance programs influence and impact the design, manufacture, and installation of power and control cables and have a significant effect on service life.

Achieving desired quality during the manufacture of any cable or cable assembly is dependent upon the use of high-quality materials and state-of-the-art processes for such categories as:

- raw materials
- handling
- compounding
- extrusion technology
- curing processes
- acceptance testing.

Programs to assure quality and cable conformance are normally adopted by a manufacturer to ensure full conformance to applicable standards.

Other topics relating to quality and testing included in Clause 11 are:

- Application of Standards
- Testing Programs
- Factory Tests
- Field Acceptance Tests
- Maintenance Tests
- Special Tests
- Reports and Documentation
- Interpretation of Results.

Reference to these topics will provide much additional information on steps to insure the receipt of quality cable as well as tests after installation.

Special-Purpose Cables (Clause 12)

Clause 12 of the guide includes information on special purpose cables used in petrochemical plants that are outside the power and control categories covered in Clause 3.

Instrument Cable

Included in this category are single and multiconductor instrumentation cables, as well as thermocouple extension cables. Instrumentation cables are either single or multiconductor cables comprised of twisted pairs or triads that convey low-energy or power-limited electrical signals from field devices to process analyzers, controllers, or some form of distributed control system (DCS). These signals are used to control and monitor equipment in process facilities and electric power systems. They function as the electrical pathway for connecting the nonmechanical elements of the feedback control loop to the input and output devices.

Circuit Classifications

Class 1, 2, and 3 circuit conductors are described, and references are made to applicable NEC articles. Wiring methods, installation, and other related information on these types of circuits is provided.

Cable Descriptions and Types

The following types of instrument cable are described in detail and cross referenced to applicable NEC articles, together with application information:

- 300-V power limited tray cable, Type PLTC
- 300-V instrumentation tray cable, Type ITC
- 600-V tray cable, Type TC
- Thermocouple extension cable, Types PLTC, ITC, and TC.

Fiber-Optic Cables

Fiber-optic cables have been developed in recent years and have gained rapid acceptance. Now, such cables are in demand as a necessity for high-speed communication and data transmission. Fiber-optic cables have properties that are very different, and superior in many respects, when compared to metallic conductor cables.

The following topics are included for fiber-optic cables:

- construction
- core/cladding design
 - multimode step-index
 - single-mode step-index
 - multimode graded-index
- terminations.

Coaxial Cables

Coaxial cables also see frequent use. They consist of a conductor centered inside a metallic tube, braid, or shield separated by a dielectric. The inner conductor is typically referred to as the conductor or center conductor. The outer conductor is typically referred to as the shield. Coaxial cables typically have a jacket over the shield. Coaxial cables are normally used for closed-circuit TV systems, computer network cables, security systems, etc.

Voice and Data Cables

Voice and data cables are used for many purposes in industrial applications.

Premise Cables

Premise telephone and data cables are generally supplied with two, three, or four conductor pairs for runs to individual telephones or with eight, 12, 25, 50, 100, or 200 pairs for distribution purposes. Cable construction often includes twisted pair, 24-gauge, bare copper conductors; color-coded, polyethylene insulation; and a PVC jacket. For plenum use, fluoropolymer materials are normally utilized to minimize fire risk. Larger conductor sizes are available. For data transmission, cables rated as Category 5, or higher, should be considered.

Outside Plant Cables

Outside plant cables are generally installed aerially, in ducts, or direct buried and provide the means for connecting central office switching facilities to buildings and plant facilities throughout the complex. Such cables are often referred to as exchange cables. Frequently, they are furnished and installed by local telephone companies. There are many types, such as air core, filled core, self support, and aluminum, steel, polyethylene (ASP) sheath.

Intercom and Audio Cables

Intercom and audio cables are available in numerous constructions. The typical types are one or two pair, one through eight individual conductors, and some combination of pairs and individual conductors. Some of the individual conductor cables may have conductors of different size within the same cable.

Cables for Hazardous Areas

Cables for hazardous areas must be carefully selected to meet NEC requirements. In the petroleum and chemical industries, hazardous materials are predominantly flammable or combustible gases, vapors, and liquids. The acceptability of cables in hazardous areas depends not only on the type of cable, but also on the type of circuit they support and the type of installation method employed.

Types of Cables

Most cables are not designed to prevent flammable or combustible gases, vapors, or liquids from migrating through cable fillers and between conductors from a hazardous location to a nonhazardous location. Thus, sealing requirements differ, depending upon the type of cable selected. A listing of the types of cables most often used in hazardous areas follows:

- *Mineral-Insulated Cables:* Mineral-insulated, metal-sheathed (Type MI) cable is a factory assembly of one or more conductors insulated with highly compacted mineral insulation and enclosed in a seamless, liquid-and-gas-tight continuous copper or alloy-steel sheath. MI cable, due to its construction, has an inherent ability to block gases, vapors, and liquids.
- *Metal-Clad Cables:* The metal-clad (Type MC) cable is a factory assembly of one or more insulated circuit conductors enclosed in a metallic sheath of interlocking tape, or a smooth or corrugated tube, with or without an overall jacket of suitable polymeric material and separate grounding conductors.
- *Other Cables:* Unlike Type MI cable, other types of cables do not block the passage of flammable or combustible gases, vapors, or liquids. Therefore, conduits and seals must be used on cables to prevent the passage of such gases, vapors and liquids.



Use of rollers to minimize bend damage.

Types of Circuits

Sometimes, it is the type of circuit a cable supports that determines whether a cable is suitable for installation in hazardous areas. Two basic types of circuits exist: in a circuit type that has enough energy to ignite flammable or explosive gas or vapor mixture during faulted conditions and a circuit type that does not have enough energy to ignite hazardous gas or vapor mixture during faulted conditions. Circuit types that do not have enough energy to ignite are called intrinsically safe and non-incendive circuits.

Types of Cable Installation Methods

When the type of cable or the type of circuit it supports does not qualify for installation in a hazardous area, other means of reducing the risk of starting a fire or an explosion are used. Typically, if the cables are not suitable for installation in hazardous areas, they must be installed in conduit and properly sealed with approved fittings. Some cable types, however, are approved for installation in Class I, Division 2 and Zone 2 hazardous areas without conduit when an approved cable termination fitting is used on each end of the cable. These types include MV, MC, TC, PLTC, and ITC.

Cablebus

Cablebus is another way to utilize insulated cable for high ampacity transitions. The most common busway used in the petrochemical industry is nonsegregated phase, metal-enclosed bus, commonly called bus duct. However, when the bus duct runs are long and the currents high, the costs and installation of the bus duct, including supports, has proved to be expensive compared to other cable installation methods.

As defined by the NEC, “cablebus” is an approved assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated, protective metal housing. The assembly is designed to carry fault current and to withstand the magnetic forces of such currents.

A cablebus is different from a metal-enclosed bus in several important ways. Cablebus is more of a hybrid between cable tray and busway. It uses insulated conductors in an enclosure that is similar to a cable tray with covers. Cablebus is normally furnished as components for field assembly, but can be furnished as factory-assembled sections. Cablebus is generally not subject to expansion or contraction problems. The enclosure is normally manufactured from aluminum or steel and resembles a cable tray with ventilated bottom and top covers. The guide provides further details on types of cables, spacing, installation, etc.

Cable Installation (Clause 13)

Cable installation specifications and construction supervision is often neglected in common industry practice. Yet, cable installation damage and improper terminations and splices are widely cited as the most frequent cause of cable failures, hence, the decision to include this clause in the guide to provide a summary of installation requirements and practices along with references to more detailed specifications.

There are various considerations when installing electrical cables. Cables installed underground may be direct buried or pulled into underground conduit. Fig. 9 illustrates the use of rollers to minimize bend damage when pulling cable through manholes. Cables above ground may be installed in conduit, cable tray, or on an aerial messenger wire. For details on types of installations and other installation criteria, refer to IEEE 576-2000.

Conclusion

This guide is subject to reaffirmation or change after five years from publication. Thus, a new WG has been organized to undertake an update and expand the original guide. It is hoped that users will provide feedback so that improvements can be incorporated in the next issue. At that time, the WG may want to include some International Electrotechnical Commission standards and information on cables made to such standards. These types of cables are being used in petroleum and chemical plants in many other countries. Also, cables associated with fixed and floating offshore oil facilities should be considered, although these types of cable are included in other standards. Those interested in the contents of this guide, or other cable-related topics, including the proposed topics covered above, should give consideration to joining this WG, which has now been reactivated under PCIC sponsorship with a companion WG in the PES/ICC organization.

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