UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 26 - ELECTRICAL

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ATTACHMENTS:

wire table

-- End of Section Table of Contents --

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USACE / NAVFAC / AFCEC / NASA	**UFGS-26 05 19.10 10 (May 2016)**

Preparing Activity: USACE	**Superseding**
	UFGS-26 05 19.00 10 (November 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021

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SECTION 26 05 19.10 10

INSULATED WIRE AND CABLE
05/16

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NOTE: This guide specification covers the requirements for insulated wire and cable for use on hydraulic structures, except for wire and cable for special applications, such as low-level circuits for analog signals, data and supervisory control, communication and telemetering systems. Specification of wire and cable for special applications may be found in other technical guide specifications for the system to which the wire and cable will be applied. Otherwise, the designer must develop and write specifications listing the salient characteristics for the basis of design of the special wire and cable needed.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

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NOTE: Procurement documents, including specifications, plans, and wire tables, should be prepared to include relevant portions of the information checklists stated below. The first list, "Characteristics of Systems on Which Cable Is

To Be Used," would be applicable where insulated wire and cable are to be procured via a construction contract, particularly where the Contractor is expected to decide details such as wire size, etc. It may be used in a supply contract for those purchases where all the characteristics are known in advance such that they can be specified in detail. The items of the second list, "Quantities and Description of Cable," are covered in general in these guide specifications, and should be applicable when procuring insulated wire and cable via supply or construction contracts. These items should be verified or specified in the level of detail needed for each particular case.

1). Characteristics of Systems on Which Cable Is To Be Used.

a. Normal operating voltage between conductors.
b. Frequency.
c. Number of phases & conductors.
d. Cable insulation level [100 percent][133 percent] or [173 percent].

(NOTE for characteristic d. only: 600 Volt AC low voltage cables typically do not require in-service voltage stress consideration and require only 100 Percent Insulation Level. However, there may be some special applications for cables rated 2,000 Volts and less where the designer must consider the in-service voltage stress, determine and insert the proper insulation level into this specification section. Refer to ANSI/NEMA WC 70 for additional descriptions regarding "Insulation Levels" for wire and cables rated 2,000 Volts and below.

The in-service voltage stress must be considered and specified for wire and cables rated 2,001 Volts to 5,000 Volts. The designer must consider the in-service voltage stress, determine and insert the proper insulation level into this specifications section. Refer to ANSI/ANSI/NEMA WC 71/ICEA S-96-659 for additional descriptions regarding "Insulation Levels." for wire and cables rated 2,001 Volts to 5,000 Volts.

The in-service voltage stress must be considered and specified for wire and cables rated 5,001 Volts and above. The designer must consider the in-service voltage stress, determine and insert the proper insulation level into this specifications section. Refer to NEMA WC 74/ICEA S-93-639 for additional descriptions regarding "Insulation Levels." for wire and cables rated 5,000 Volts to 46,000 Volts.")

e. Minimum and maximum temperatures at which cable is expected to be operated.
f. Description of installation.
1.In cable trays.

2.In ducts.
3.Other.
g. Conditions of installation.
1.Ambient temperature.
2.Wet or dry location.
3.Number of loaded cables in cable trays, duct bank, or conduit. If in conduit, provide type of conduit (metallic or non-metallic), number of loaded circuits, whether conduit is enclosed or run exposed, and spacing between conduits.
4.Load factor.
5.Method of bonding and grounding of metallic coverings (including shields).
6.Chemical exposure.

2). Quantities and Description of Cable.

a. Total number of meters feet, including lengths for customer testing, and lengths if specific lengths are required.
b. Type of cable. Describe as single-conductor, two-conductor, etc.
c. Rated circuit voltage, phase to phase.
d. Type of conductors - copper or aluminum.
e. Size of conductors - AWG or circular micrometers (mils). If conditions require other than standard stranding, a complete description should be given.
f. Grade of insulation.
g. Thickness of insulation, in micrometers mils.
h. Type of outer covering.
i. Maximum allowable overall diameter, in mm inches. When duct space is not limited, it is not wise to restrict the overall diameter.
j. Method of conductor identification.

In making wiring layouts for those installations using multiple-conductor cables, care should be taken to avoid the use of assemblies not normally stocked by manufacturers, or of small quantities which will not come within the manufacturers' minimum pricing schedules. In general, unless very large quantities are involved, lower overall cable costs can be effected by using manufacturers' standard assemblies, even though more conductors than required are provided, instead of a cable requiring a special setup. Short lengths may be eliminated by substituting cables which will have sufficient quantity to obtain the manufacturers' minimum price. Substitution may consist of a larger number of conductors than required, or a combination of assemblies of a smaller number of conductors. The most economical cable schedule for any particular installation can be obtained only by careful study of all factors involved, particularly increased conduit costs.
****

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1202	(2006; R 2012; CORR 1 2012) Flame-Propagation Testing of Wire and Cable

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-58-679	(2014) Control, Instrumentation and Thermocouple Extension Conductor Identification
ICEA T-30-520	(1986) Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input Rate of 70,000 B.T.U./Hour

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA WC 71/ICEA S-96-659	(2014) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA WC 26	(2008) Binational Wire and Cable Packaging Standard
NEMA WC 57	(2014) Standard for Control, Thermocouple Extension, and Instrumentation Cables
NEMA WC 70	(2009) Power Cable Rated 2000 V or Less for the Distribution of Electrical Energy--S95-658
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for

	Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 44	(2018) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 1685	(2015) UL Standard for Safety Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables
UL 2556	(2015) UL Standard for Safety Wire and Cable Test Methods

1.2 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Wire and Cable; G[, [____]]

Conductors; G[, [____]]

Cable Manufacturing Data

SD-06 Test Reports

Test Report(s), Inspection Report(s), and Verification Report(s); G [, [_____]]

1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, must be plainly marked or tagged to indicate the cable length, voltage rating, conductor size, and manufacturer's lot number and reel number. Each coil or reel of cable must contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in paragraph "High-Voltage Test Source," must be identified as such. Shielded cables rated 2,001 volts and above must be reeled and marked in accordance with NEMA WC 26, as applicable. Reels must remain the property of the [Contractor] [Government].

1.4 PROJECT/SITE CONDITIONS

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NOTE: Use this paragraph to describe unusual environments, such as temperature extremes, chemical exposure, etc.
****

[_____]

PART 2 PRODUCTS

2.1 MATERIALS

****
NOTE: Variations from these specifications may be appropriate in some cases. In addition to increasing rated circuit voltage where large overvoltages could occur, material sizes and strengths should be coordinated to withstand any pulling forces which will be applied. The lower

strength of EPR, even jacketed, may at times preclude the use of this material for long pulls. If variations are requested by a Contractor, they should only be approved if the safety and integrity of conservatively designed circuits are not compromised. The use of polyvinyl chloride (PVC) insulation or jacket material is not permitted.
****

2.1.1 Wire Table

****
NOTE: An example typical wire table and a Format Template for a Wire Table are located at the end of this Section. Use this paragraph and Format Template, if itemized characteristics for each application are to be tabulated.
****

Furnish wire and cable in accordance with the requirements of the [wire table below] [wire table appended to these specifications], conforming to the detailed requirements specified herein.

2.1.2 Rated Circuit Voltages

All power wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Power wire and cable for circuit voltages rated 0-600 volts must be rated not less than 600 volts. Control wire and cable must have minimum rated circuit voltages in accordance with NEMA WC 57, but must be rated 600 volts if routed in raceway with other conductors that are rated 600 volts.

2.1.3 Conductors

****
NOTE: "Electrical conductors and cables must not propagate flame and must be rated as such by passing or being capable of passing one or more of the following applicable tests.

All electrical cable assemblies (multiple-conductor and single-conductor) must pass, or be capable of passing either the vertical cable tray flame tests required by ICEA T-30-520 (as stated in, but not referred to by NEMA WC 70), the vertical tray flame propagation test requirements of UL 1685 and IEEE Std. 1202, the wire and cable burning characteristics test of the UL 2556 VW-1 Test, or (for control cables only) the flame test as required by NEMA WC 57. (The flame testing requirement was previously restricted to cable tray applications. It is extended to all uses for greater safety, since flame-resistant cables are now available from many manufacturers.)
****

2.1.3.1 Material for Conductors

****

NOTE: If aluminum is to be specified for any of the wire purchased, revise the paragraphs accordingly.

Conductors for wire and cable may be aluminum or copper. Aluminum conductors may be considered for use in accordance with NFPA 70, Article 310.106. When used, aluminum conductor material must be AA-8000 series electrical grade aluminum alloy. The designer must consider several factors when deciding to use aluminum instead of copper including comparisons of electrical properties, mechanical properties, environmental properties specific to the intended installation, reliability, and cost. Specifications for wire and cable may be written to permit either aluminum or copper conductors where aluminum is suitable for the application, suitably reliable, and is determined to be more economical than copper.

Aluminum conductors should be permitted only where cost comparisons show an overall savings and after a careful evaluation of the corrosion problems associated with their use. They should only be allowed where installers are qualified to make reliable connections with them. Proper wire and cable connectors must be suitably rated for installation with the conductor material to which they are applied. Wire and cable connectors used with aluminum conductors must be suitably rated, termination must be prepared correctly, and an antioxidant must be applied when the connector is installed. Costs should be compared to between all pertinent items such as installation, conduit, tray, tunnel and duct banks, lifetime costs of energy losses if significant, and differences in ventilation needs if losses are evaluated. Conductors should have the required current carrying capacities, the required short circuit capacities, and should be satisfactory with respect to voltage drop. Aluminum conductors should be sized to have equal or less resistance than the alternate copper conductors unless the total cost comparison, including losses, shows a net advantage otherwise. In such cases where the engineering costs to properly compare the use of the two materials will exceed any possible savings to be achieved by aluminum, the arbitrary choice of copper may be the best policy.

****

Conductors must conform to all the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Copper conductors must be annealed copper material and they may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used. [Aluminum conductors must be Type AA-8000 aluminum conductors. Type 1350 is not acceptable. Intermixing of copper and

aluminum conductors in the same raceway is not permitted.]"

2.1.3.2 Size

Minimum wire size must be No. 12 AWG for power and lighting circuits; No. 10 AWG for current transformer secondary circuits; No. 14 AWG for potential transformer, relaying, and control circuits; No. 16 AWG for annunciator circuits; and No. 19 AWG for alarm circuits. Minimum wire sizes for rated circuit voltages of 2,001 volts and above must not be less than those listed for the applicable voltage in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.3 Stranding

Conductor stranding classes cited herein must be as defined for control conductors in NEMA WC 57 or as defined for 0-2,000 volts power conductors in NEMA WC 70, as applicable. Lighting conductors No. 10 AWG and smaller must be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, must have Class H or K stranding. All other conductors must have Class B or C stranding, except that conductors as shown, or in the schedule, as No. 12 AWG may be 19 strands of No. 25 AWG, and conductors shown as No. 10 AWG may be 19 strands of No. 22 AWG. Conductor stranding classes for circuit voltages 2,001 volts and above must be as defined in ANSI/NEMA WC 71/ICEA S-96-659 and NEMA WC 74/ICEA S-93-639, as applicable.

2.1.3.4 Conductor Shielding

Use conductor shielding conforming to NEMA WC 57 for control wire and cable as applicable. Use conductor shielding conforming to ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable, on power cables having a rated circuit voltage above 2,000 volts.

2.1.3.5 Separator Tape

Where conductor shielding, strand filling, or other special conductor treatment is not required, a separator tape between conductor and insulation is permitted.

2.1.4 Insulation

2.1.4.1 Insulation Material

****

For project applications which require a different insulation than those listed below, reference a Government criteria or an industry standard that the cable or conductor must meet. For projects which require multiple types of insulations, indicate the type for each cable on the project drawings.

The insulation compounds specified herein are of the thermoplastic and thermosetting type. Thermoplastic insulation types such as THHN, THWN, and THWN-2 must meet the requirements of UL 83 and is typical for circuit voltage ratings of 600 volts. Thermosetting insulation type options include cross-linked thermosetting polyethylene (XLPE) and ethylene-propylene rubber (EPR) which must meet the

requirements of UL 44. These two materials alone are widely available and can be satisfactorily compounded to meet the requirements of a conservative cable design for long and reliable service. Cross-linked thermosetting polyethylene insulation types include XHHW and RHW. XHHW type insulation provides good thermal expansion and contraction characteristics applicable for power and control conductors with circuit voltage ratings of 2,000 volts or less in installations exposed to large temperature changes or installed outdoors subject to weather cycles from hot summer to cold winter temperatures. XLPE is applicable for all circuit voltage ratings. EPR is applicable to wire and cable for circuit voltages rated greater than 2,000 volts. The insulation grades permitted must be suitable for service in wet or dry locations at 90 C. This specification does not allow the use of "tray cable" meeting only the minimum requirements of the National Electrical Code or Underwriters Laboratories, which permit a 75 C wet rating. Jackets are also thermosetting, except certain thermoplastic compounds are permitted for use below 601 volts, as defined in paragraph JACKET MATERIAL, subparagraph ACCESSIBLE USE ONLY, 2,000 VOLTS OR LESS, in cases where access for cable installation and removal would not be a problem.
****

Unless specified otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, [Type THWN/THHN conforming to UL 83] [or] [Type [XHHW] [or] [RHW] conforming to UL 44]. Insulation for control wire and cable must meet the requirements of NEMA WC 57. Insulation requirements for wire and cable rated less than 2,000 volts must meet the requirements of NEMA WC 70. Insulation requirements for wire and cable rated 2,001-5,000 volts must meet the requirements of ANSI/NEMA WC 71/ICEA S-96-659. Insulation requirements for wire and cable rated 5,001 volts and greater must meet the requirements of NEMA WC 74/ICEA S-93-639.

For shielded cables of rated circuit voltages above 2,000 volts, the following provisions must also apply:

a. XLPE, if used, must be tree-retardant.

b. Insulation must be chemically bonded to conductor shielding.

c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes must all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material must be inspected for voids and contaminants.

d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are prohibited [unless specifically approved].

2.1.4.2 Insulation Thickness

****

NOTE: The rated circuit voltage of the insulation should be specified to be 600 volts for all circuits operating below 601 volts. Higher rated circuit voltages may be required by some applications within this range, such as control circuits containing large dc solenoids used in older circuit breakers. Specifications should then be revised to require 1,000- or 2,000-volt insulation in such cases for multiple- or single-conductor cables, respectively. Below 48 volts, 600-volt insulation can be used, but these are special applications that are best considered in light of the particular circumstances. For example, many proprietary detection systems and programmable controller applications typically use 24-volt, low-power circuits, for which lower rated circuit voltages may be appropriate. These specifications also cover rated circuit voltages for systems operating above 600 volts.

****

The insulation thickness for each conductor must be based on its rated circuit voltage.

2.1.4.2.1 Power Cables, 2,000 Volts and Below

The insulation thickness for single-conductor and multiple-conductor power cables rated 2,000 volts and below must be as required by NEMA WC 70, as applicable. Some thicknesses of NEMA WC 70 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 70 ethylene-propylene rubber-insulated conductors must have a jacket.

2.1.4.2.2 Power Cables, Rated 2,001 Volts and Above

Thickness of insulation for power cables rated 2,001 volts and above must be in accordance with the following

a. Non-shielded cables, 2,001 to 5,000 volts, must comply with ANSI/NEMA WC 71/ICEA S-96-659, as applicable.

b. Shielded cables rated 5,000 volts to 46,000 volts must comply with NEMA WC 74/ICEA S-93-639, as applicable.

2.1.4.2.3 Single-Conductor and Multiple-Conductor Control Cables

The insulation thickness of control conductor sizes 22 AWG to 10 AWG used for control and related purposes must be as required by NEMA WC 57, as applicable. Control conductors larger than 10 AWG must be as required by NEMA WC 70.

2.1.4.3 Insulation Shielding

Unless otherwise specified, provide insulation shielding for conductors having rated circuit voltages of 2,001 volts and above. The voltage limits above which insulation shielding is required, and the material

requirements, are given in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The material, if thermosetting, must meet the wafer boil test requirements as described in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The method of shielding must be in accordance with the current practice of the industry; however, the application process must include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield must not exceed the maximum allowances specified in ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable. The cable must be capable of operating without damage or excessive temperature when the shield is grounded at both ends of each conductor. All components of the shielding system must remain tightly applied to the components they enclose after handling and installation in accordance with the manufacturer's recommendations. Shielding systems which require heat to remove are prohibited unless specifically approved.

2.1.5 Jackets

All cables must have jackets meeting the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, and NEMA WC 74/ICEA S-93-639, as applicable, and as specified herein. Individual conductors of multiple-conductor cables must be required to have jackets only if they are necessary for the conductor to meet other specifications herein. Jackets of single-conductor cables and of individual conductors of multiple-conductor cables, except for shielded cables, must be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables must be provided with a common overall jacket, which must be tightly and concentrically formed around the core. Repaired jacket defects found and corrected during manufacturing are permitted if the cable, including jacket, afterward fully meets these specifications and the requirements of the applicable standards.

2.1.5.1 Jacket Material

****

NOTE: Modify the restriction against PVC Jackets if they will be permitted on metal-clad cables, in accordance with paragraph METAL-CLAD CABLE, subparagraph JACKETS.

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The jacket must be one of the materials listed below. [Polyvinyl chloride compounds will not be permitted.] [Variations from the materials required below will be permitted only if approved for each specific use, upon submittal of sufficient data to prove that they exceed all specified requirements for the particular application.]

2.1.5.1.1 General Use

Heavy-duty black neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty chlorosulfonated polyethylene	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Heavy-duty cross-linked (thermoset) chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.1.2 Accessible Use Only, 2,000 Volts or Less

Cables installed where they are entirely accessible, such as cable trays and raceways with removable covers, or where they pass through less than 3 meters10 feet of exposed conduit only, must have jackets of one of the materials in item "a. General Use" or one of the following:

General-purpose neoprene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Black polyethylene (MDPE)	NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639
Thermoplastic chlorinated polyethylene	NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639

2.1.5.2 Jacket Thickness

The minimum thickness of the jackets must be not less than 80 percent of the respective nominal thicknesses specified below.

2.1.5.2.1 Multiple-Conductor Cables

Thickness of the jackets of the individual conductors of multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable and must be in addition to the conductor insulation thickness required by the applicable respective NEMA publication for the insulation used. Thickness of the outer jackets and associated coverings of the assembled multiple-conductor cables must be as required by NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.5.2.2 Single-Conductor Cables

Single-conductor cables must have a jacket thickness as specified in

NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable.

2.1.6 Metal-Clad Cable

2.1.6.1 General

The metallic covering or sheath must be [interlocked metal tape] [continuous corrugated metal], conforming to the applicable requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. The type of metal for the metallic covering must be [galvanized steel] [aluminum] [copper] [copper alloy]. If the covering is of ferrous metal, it must be galvanized. Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor metal-clad cable. Assembly and cabling must be as specified in paragraph "Cabling." The metallic covering must be applied over an inner jacket or filler tape. The cable must be assembled so that the metallic covering will be tightly bound over a firm core.

2.1.6.2 Jackets

Metal-clad cables may have a jacket under the armor, and must have a jacket over the armor. Jackets must comply with the requirements of NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. The outer jacket for the metal-clad cable may be of polyvinyl chloride (PVC) only if specifically approved.

2.1.7 Multiple-Conductor Cables

Grounding conductor(s) conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable must be furnished for each multiple-conductor cable. Assembly and cabling must be as specified in paragraph CABLING.

2.2 CABLE IDENTIFICATION

2.2.1 Color-Coding

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NOTE: The Control wire and cable color code previously referred to NEMA WC 70, however NEMA WC 70 now refers to ICEA S-58-679. Note that NEMA WC 57 applies specifically to control wire and cable industry standards and also includes recommendations for conductor color coding that are color code methods listed in ICEA S-58-679. The control cable color code specified, although widely used by the Corps of Engineers, does not agree with National Electrical Code requirements of dedicated white color for neutral conductor identification and dedicated green color or green/yellow for grounding conductor identification. If this is required, use the coding in either Table 2 or Table 4 in ICEA S-58-679.

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Insulation of individual conductors of multiple-conductor cables must be color-coded in accordance with ICEA S-58-679, except that colored braids will not be permitted. Only one color-code method must be used for each cable construction type. Control cable color-coding must be [in accordance with ICEA S-58-679, Method [____]] [as indicated] [as follows: - [_____]]. Power cable color-coding must be black for Phase A, red for Phase B, blue for Phase C, white for grounded neutral, and green for an insulated grounding conductor, if included. [Other individual conductors must be color-coded as indicated, but such color-coding may be accomplished by applying colored plastic tapes or colored sleeves at terminations.]

2.2.2 Shielded Cables Rated 2,001 Volts and Above

Marking must be in accordance with ANSI/NEMA WC 71/ICEA S-96-659 or NEMA WC 74/ICEA S-93-639, as applicable.

2.2.3 Cabling

Individual conductors of multiple-conductor cables must be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639. Flat twin cables are prohibited. Fillers must be used in the interstices of multiple-conductor round cables with a common covering where necessary to give the completed cable a substantially circular cross section. Fillers must be non-hygroscopic material, compatible with the cable insulation, jacket, and other components of the cable. The rubber-filled or other approved type of binding tape must consist of a material that is compatible with the other components of the cable and must be lapped at least 10 percent of its width.

2.2.4 Dimensional Tolerance

The outside diameters of single-conductor cables and of multiple-conductor cables must not vary more than 5 percent and 10 percent, respectively, from the manufacturer's published catalog data.

PART 3 EXECUTION

3.1 INSTALLATION INSTRUCTIONS

Submit cable manufacturing data [as requested]. The following information must be provided by the cable manufacturer for each size, conductor quantity, and type of cable furnished:

a. Minimum bending radius, in inches - For multiple-conductor cables, this information must be provided for both the individual conductors and the multiple-conductor cable.

b. Pulling tension and sidewall pressure limits, in newtons pounds.

c. Instructions for stripping semiconducting insulation shields, if furnished, with minimum effort without damaging the insulation.

d. Upon request, compatibility of cable materials and construction with specific materials and hardware manufactured by others must be stated. Also, if requested, recommendations must be provided for various cable operations, including installing, splicing, terminating,

etc.

3.2 TEST REPORT(S), INSPECTION REPORT(S), AND VERIFICATION REPORT(S)

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NOTE: Contract schedules should allow sufficient time for an orderly and timely sequence of data submission, manufacturing of equipment and materials, and delivery in accordance with the specifications. However, there may be occasions when wire and cable must be obtained in such a short time that compliance with the requirements of this paragraph and subparagraphs CABLE DATA and INSPECTIONS AND TESTS, is not practical. In those cases, wire and cable from suppliers' stock may be considered for approval, provided a manufacturer's certificate is submitted, which establishes to the satisfaction of the Contracting Officer that the proposed wire and cable, identified by lot number and reel or coil number, meet the applicable standards and specifications. Such deviations should be limited to those cases in which a contract change or incorrect estimate requires the procurement of cable which, if done following the specified approval procedure, would result in unacceptable contract completion dates.

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3.2.1 Cable Data

Do not begin any wire and cable fabrication until materials are submitted and approved by the Contracting Officer. Submit cable data for approval including, but not limited to, dimensioned sketches showing cable construction and sufficient additional data to show that wire and cable meet the requirements of this Section.

3.2.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications must be made by and at the plant of the manufacturer, [and must be witnessed by the Contracting Officer, unless waived in writing.] [and the manufacturer must provide certification and certification reports of completed inspections and completed tests.] The Government may require or perform further tests before or after installation. Testing in general must comply with NEMA WC 57, NEMA WC 70, ANSI/NEMA WC 71/ICEA S-96-659, or NEMA WC 74/ICEA S-93-639 as applicable. Specific tests required for particular materials, components, and completed cables must be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests must also be performed in accordance with the additional requirements specified below. Submit [_____] certified copies of test reports.

3.2.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits must be made with dc test voltages. Cables to be used exclusively on ac circuits must be tested with ac test voltages. If both ac and dc will be present, on either the same or separate conductors of the cable, ac test voltages must be used.

3.2.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following test(s) must be performed in addition to those specified above:

a. If high-voltage testing is done with an AC test voltage as specified in paragraph "High-Voltage Test Source," an additional test must be made using a DC test voltage rated at 75 percent of the specified full DC test voltage, for 5 consecutive minutes.

b. If voltage tests after installation are required for 5-65kV shielded power cables then testing must be done in accordance with NEMA WC 74/ICEA S-93-639, Appendix F.

3.2.2.3 Flame Tests

All [multiple-conductor and single-conductor] cable assemblies must pass either the vertical cable tray flame tests required by ICEA T-30-520 (stated in, but not required by NEMA WC 70), the vertical tray flame propagation test requirements of UL 1685 and IEEE 1202, the wire and cable burning characteristics test of the UL 2556 VW-1 Test, or (for control cables only) the flame test as required by NEMA WC 57. If such tests, however, have previously been made on identical cables, these tests need not be repeated. Instead, certified reports of the original qualifying tests must be submitted. In this case the reports furnished under paragraph "Reports," must include information, identify critical information, and verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

3.2.2.4 Independent Tests

The Government may make visual inspections, continuity or resistance checks, insulation resistance readings, power factor tests, or dc high potential tests at field test values. A cable's failure to pass these tests and inspections, or failure to produce readings consistent with acceptable values for the application, will be grounds for rejection of the cable.

3.2.2.5 Reports

Furnish results of tests. No wire or cable must be shipped until authorized. Lot number and reel or coil number of wire and cable tested must be indicated on the test reports.

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Example Typical Wire Table:

WIRE TABLE						
Item No.	**Size, kcmil AWG**	**No. of Conds.**	**Rated Circuit Voltage**	**Stranding**	**Comments**	**Quantity, m lin ft**
1	**12**	**1**	**600**	**B or C**	**general use**	**3260**

WIRE TABLE						
Item No.	Size, kcmil AWG	No. of Conds.	Rated Circuit Voltage	Stranding	Comments	Quantity, m lin ft
2	12	1	600	* Solid	lighting	960
3	10	4	1000	B or C	transformers	120
4	2/0	shield, armor, 3	15 kV	B or C	jacket	275
17	12	9	1000	B or C	control annunciation	670
Class [_____] stranding may be substituted for [_____] where indicated by "*".						

***NOTE: Cable quantities for construction contracts should only be listed when certain, unless payment is to be per m foot, or if they are stated to be approximate, subject to Contractor verification.
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WIRE TABLE						
Item No.	Size, AWG or kcmil	No. of Conds.	Rated Circuit Voltage	Stranding	Comments	Quantity, m lin ft
Class [_____] stranding may be substituted for [_____] where indicated by "*".						

-- End of Section --