

\*\*\*\*\*  
USACE / NAVFAC / AFCESA UFGS-16120A (November 1991)  
-----  
Preparing Activity: USACE (CW) Replacing without revision  
CEGS of same number and date

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

\*\*\*\*\*

### SECTION TABLE OF CONTENTS

#### DIVISION 16 - ELECTRICAL

#### SECTION 16120A

#### INSULATED WIRE AND CABLE

11/91

#### PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 DELIVERY, STORAGE, AND HANDLING
- 1.4 PROJECT/SITE CONDITIONS

#### PART 2 PRODUCTS

- 2.1 MATERIALS
  - 2.1.1 Wire Table
  - 2.1.2 Rated Circuit Voltages
  - 2.1.3 Conductors
    - 2.1.3.1 Material
    - 2.1.3.2 Size
    - 2.1.3.3 Stranding
    - 2.1.3.4 Conductor Shielding
    - 2.1.3.5 Separator Tape
  - 2.1.4 Insulation
    - 2.1.4.1 Insulation Material
    - 2.1.4.2 Insulation Thickness
    - 2.1.4.3 Insulation Shielding
  - 2.1.5 Jackets
    - 2.1.5.1 Jacket Material
    - 2.1.5.2 Jacket Thickness
  - 2.1.6 Metal-Clad Cable
    - 2.1.6.1 General
    - 2.1.6.2 Jackets
  - 2.1.7 Identification
    - 2.1.7.1 Color-coding
    - 2.1.7.2 Shielded Cables Rated 2,001 Volts and Above
  - 2.1.8 Cabling
  - 2.1.9 Dimensional Tolerance
- 2.2 INSTALLATION INSTRUCTIONS
- 2.3 TESTS, INSPECTIONS, AND VERIFICATIONS
  - 2.3.1 Cable Data

2.3.2 Inspection and Tests

2.3.2.1 High-Voltage Test Source

2.3.2.2 Shielded Cables Rated 2,001 Volts or Greater

2.3.2.3 Flame Tests

2.3.2.4 Independent Tests

2.3.2.5 Reports

PART 3 EXECUTION (Not Applicable)

-- End of Section Table of Contents --

\*\*\*\*\*  
USACE / NAVFAC / AFCESA UFGS-16120A (November 1991)  
-----  
Preparing Activity: USACE (CW) Replacing without revision  
CEGS of same number and date

## UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

\*\*\*\*\*

### SECTION 16120A

#### INSULATED WIRE AND CABLE 11/91

\*\*\*\*\*

NOTE: This guide specification covers all insulated wire and cable for use on Civil Works hydraulic structures of the Corps of Engineers, except for wire and cable for special applications, such as low-level circuits for analog signals, data and supervisory control, communication and telemetering systems.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

\*\*\*\*\*

## PART 1 GENERAL

\*\*\*\*\*

NOTE: See Additional Note A.

\*\*\*\*\*

### 1.1 REFERENCES

\*\*\*\*\*

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

\*\*\*\*\*

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.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

- |          |                                                                                                   |
|----------|---------------------------------------------------------------------------------------------------|
| AEIC CS5 | (1994; CS5a-1995) Cross-Linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 46 kV |
| AEIC CS6 | (1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 69 kV                      |

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- |              |                                                                                                                           |
|--------------|---------------------------------------------------------------------------------------------------------------------------|
| IEEE Std 383 | (1974; R 1992) Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations |
|--------------|---------------------------------------------------------------------------------------------------------------------------|

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- |           |                                                                                                                                                   |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| NEMA WC 7 | (1988; Rev 3 1996)<br>Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy |
| NEMA WC 8 | (1988; Rev 3 1996)<br>Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy               |

1.2 SUBMITTALS

\*\*\*\*\*

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

\*\*\*\*\*

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

#### SD-03 Product Data

##### Installation Instructions

The Contractor shall submit cable manufacturing data [as requested].

#### SD-06 Test Reports

##### Tests, Inspections, and Verifications

[\_\_\_\_\_] certified copies of test reports shall be submitted by the contractor.

### 1.3 DELIVERY, STORAGE, AND HANDLING

Furnish cables on reels or coils. Each cable and the outside of each reel or coil, shall 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 shall contain only one continuous cable without splices. Cables for exclusively dc applications, as specified in paragraph HIGH VOLTAGE TEST SOURCE, shall be identified as such. Shielded cables rated 2,001 volts and above and shall be reeled and marked in accordance with Section I of AEIC CS5 or AEIC CS6, as applicable. Reels shall remain the property of the [Contractor] [Government].

### 1.4 PROJECT/SITE CONDITIONS

\*\*\*\*\*

NOTE: Use this paragraph to describe unusual environments, such as temperature extremes, chemical exposure, etc., per Additional Note B. Use paragraph WIRE TABLE and Format Template for Section 16120A INSULATED WIRE AND CABLE, if itemized characteristics for each application are to be tabulated.

\*\*\*\*\*

## PART 2 PRODUCTS

### 2.1 MATERIALS

#### 2.1.1 Wire Table

\*\*\*\*\*  
**NOTE: An example typical wire table is included as Additional Note L. A Format Template for Section 16120A INSULATED WIRE AND CABLE, for a Wire Table is located in the Template Menu for UFGS.**  
\*\*\*\*\*

Wire and cable shall be furnished in accordance with the requirements of the wire table [below] [appended to these specifications], and shall conform to the detailed requirements specified herein.

#### 2.1.2 Rated Circuit Voltages

All wire and cable shall have minimum rated circuit voltages in accordance with Table 3-1 of NEMA WC 7 or NEMA WC 8.

#### 2.1.3 Conductors

##### 2.1.3.1 Material

\*\*\*\*\*  
**NOTE: See Additional Notes C and D at the end of this section, concerning the use of aluminum conductors for wire above 2 kV. If aluminum is to be specified for any of the wire purchased, revise this paragraph accordingly.**  
\*\*\*\*\*

Conductors shall conform to all the applicable requirements of Section 2 of NEMA WC 7 or Part 2 of NEMA WC 8 as applicable and shall be annealed copper. Copper conductors may be bare, or tin- or lead-alloy-coated, if required by the type of insulation used.

##### 2.1.3.2 Size

Minimum wire size shall 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 shall not be less than those listed for the applicable voltage in Table 3-1 of Section 3 of NEMA WC 7 or Part 3 of NEMA WC 8, as applicable.

##### 2.1.3.3 Stranding

Conductor stranding classes cited herein shall be as defined in Appendix L of NEMA WC 7 or NEMA WC 8, as applicable. Lighting conductors No. 10 AWG and smaller shall be solid or have Class B stranding. Any conductors used between stationary and moving devices, such as hinged doors or panels, shall have Class H or K stranding. All other conductors shall have Class B or C stranding, except that conductors shown on the drawings, 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.

#### 2.1.3.4 Conductor Shielding

Conductor shielding conforming to paragraph 2.7 of NEMA WC 7 or NEMA WC 8, as applicable, shall be used on power cables having a rated circuit voltage above 2,000 volts. In addition, conductor shielding for shielded cables shall also comply with Section C of AEIC CS5 or AEIC CS6. Strict precautions shall be taken after application of the conductor shielding to prevent the inclusion of voids or contamination between the conductor shielding and the subsequently applied insulation.

#### 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

Insulation shall be cross-linked thermosetting polyethylene (XLPE) type, meeting the requirements of Section 3 or paragraph 7.7 of NEMA WC 7 as applicable, or an ethylene-propylene rubber (EPR) type meeting the requirements of Part 3 of NEMA WC 8. For shielded cables of rated circuit voltages above 2,000 volts, the following provisions shall also apply:

- a. XLPE, if used, shall be tree-retardant.
- b. Insulation shall be chemically bonded to conductor shielding.
- c. The insulation material and its manufacturing, handling, extrusion and vulcanizing processes, shall all be subject to strict procedures to prevent the inclusion of voids, contamination, or other irregularities on or in the insulation. Insulation material shall be inspected for voids and contaminants. Inspection methods, and maximum allowable void and contaminant content shall be in accordance with Section B of AEIC CS5 or AEIC CS6, as applicable.
- d. Cables with repaired insulation defects discovered during factory testing, or with splices or insulation joints, are not acceptable [unless specifically approved].

##### 2.1.4.2 Insulation Thickness

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

- a. Power Cables/Single-Conductor Control Cables, 2,000 Volts and Below - The insulation thickness for single-conductor cables rated 2,000 volts and below shall be as required by Table 3-1, Section 3 of NEMA WC 7 or Table 3-1, Part 3, of NEMA WC 8, as applicable. Column "A" thickness of Table 3-1 of NEMA WC 7 will be permitted only for single-conductor cross-linked thermosetting polyethylene insulated cables without a jacket. NEMA WC 8 ethylene-propylene rubber-insulated conductors shall have a jacket. Column "B" thickness shall apply to single-conductor cables that require a jacket and to individual conductors of multiple-conductor cables with an overall jacket.

b. Power Cables, Rated 2,001 Volts and Above - Thickness of insulation for power cables rated 2,001 volts and above shall be in accordance with the following:

(1) Non-shielded cables, 2,001 to 5,000 volts, shall comply with Note 3 to Table 3-1, of either NEMA WC 7 or NEMA WC 8, as applicable.

(2) Shielded cables rated 2,001 volts and above shall comply with Column B of Table B1, of AEIC CS5 or AEIC CS6, as applicable.

c. Multiple-Conductor Control Cables - The insulation thickness of multiple-conductor cables used for control and related purposes shall be as required by Table 7-32 of NEMA WC 7 or Table 7.5.1 of NEMA WC 8 as applicable.

#### 2.1.4.3 Insulation Shielding

Unless otherwise specified, insulation shielding shall be provided 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 Section 4 of NEMA WC 7 or Part 4 of NEMA WC 8, as applicable. The material, if thermosetting, shall meet the wafer boil test requirements as described in Section D of AEIC CS5 or AEIC CS6, as applicable. The method of shielding shall be in accordance with the current practice of the industry; however, the application process shall include strict precautions to prevent voids or contamination between the insulation and the nonmetallic component. Voids, protrusions, and indentations of the shield shall not exceed the maximum allowances specified in Section C of AEIC CS5 or AEIC CS6, as applicable. The cable shall 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 shall 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 will not be permitted unless specifically approved.

#### 2.1.5 Jackets

All cables shall have jackets meeting the requirements of Section 4 of NEMA WC 7, or Part 4 of NEMA WC 8, as applicable, and as specified herein. Individual conductors of multiple-conductor cables shall 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, shall be in direct contact and adhere or be vulcanized to the conductor insulation. Multiple-conductor cables and shielded single-conductor cables shall be provided with a common overall jacket, which shall 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.**

\*\*\*\*\*

The jacket shall 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.]

a. General Use

- (1) Heavy-duty black neoprene (NEMA WC 8, paragraph 4.4.3).
- (2) Heavy-duty chlorosulfonated polyethylene (NEMA WC 8, paragraph 4.4.10).
- (3) Heavy-duty cross-linked (thermoset) chlorinated polyethylene (NEMA WC 8, paragraph 4.4.11).

b. 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 10 feet3 meters of exposed conduit only, shall have jackets of one of the materials specified in above paragraph GENERAL USE, or the jackets may be of one of the following:

- (1) General-purpose neoprene (NEMA WC 8, paragraph 4.4.4).
- (2) Black polyethylene (NEMA WC 8, paragraph 4.4.6).
- (3) Thermoplastic chlorinated polyethylene (NEMA WC 8, paragraph 4.4.7).

2.1.5.2 Jacket Thickness

The minimum thickness of the jackets at any point shall be not less than 80 percent of the respective nominal thicknesses specified below.

a. Multiple-Conductor Cables - Thickness of the jackets of the individual conductors of multiple-conductor cables shall be as required by Section 4, Table 4-6 of NEMA WC 7 or Part 4, Table 4-4 of NEMA WC 8, and shall be in addition to the conductor insulation thickness required by Column B of Table 3-1 of the applicable NEMA publication for the insulation used. Thickness of the outer jackets or sheaths of the assembled multiple-conductor cables shall be as required by Section 4, Table 4-7, of NEMA WC 7 or Part 4, Table 4-5, of NEMA WC 8.

b. Single-Conductor Cables - Single-conductor cables, if nonshielded, shall have a jacket thickness as specified in Section 4, Table 4-4 of NEMA WC 7 or Part 4, Table 4-2 of NEMA WC 8. If shielded, the jacket thickness shall be in accordance with the requirements of Section 4, Table 4-5 of NEMA WC 7 or Part 4, Table 4-3 of NEMA WC 8.

2.1.6 Metal-Clad Cable

2.1.6.1 General

The metallic covering shall be [interlocked steel tape] [corrugated metal], conforming to the applicable requirements of section 4.5 of NEMA WC 7. If

the covering is of ferrous metal, it shall be galvanized. Copper grounding conductor(s) conforming to Section 7.8 of NEMA WC 7 shall be furnished for each multiple-conductor metal-clad cable. Assembly and cabling shall be as specified in paragraph CABLING. The metallic covering shall be applied over an inner jacket or filler tape. The cable shall 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 shall have a jacket over the armor. Jackets shall comply with the requirements of Section 4.5 of NEMA WC 7. The outer jacket for the metal-clad cable may be of polyvinyl chloride only if specifically approved.

#### 2.1.7 Identification

##### 2.1.7.1 Color-coding

\*\*\*\*\*  
**NOTE: The Control Cable Color Code specified, although widely used by the Corps of Engineers, does not agree with National Electrical Code requirements for neutral and grounding conductor identification. If this is required, use the coding in NEMA WC 8, Appendix K, Table K-2. Also refer to Appendix K for coding of pairs, if necessary.**  
\*\*\*\*\*

Insulation of individual conductors of multiple-conductor cables shall be color-coded in accordance with paragraph 5.3 of NEMA WC 8, except that colored braids will not be permitted. Only one color-code method shall be used for each cable construction type. Control cable color-coding shall be [in accordance with Table 5-2 of NEMA WC 8] [as shown on the drawings] [as follows: - [\_\_\_\_]]. Power cable color-coding shall 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 shall be color-coded as indicated on the contract drawings but such color-coding may be accomplished by applying colored plastic tapes or sleeving at terminations.]

##### 2.1.7.2 Shielded Cables Rated 2,001 Volts and Above

Marking shall be in accordance with Section H of AEIC CS5 or AEIC CS6, as applicable.

#### 2.1.8 Cabling

Individual conductors of multiple-conductor cables shall be assembled with flame-and moisture-resistant fillers, binders, and a lay conforming to Part 5 of NEMA WC 8, except that flat twin cables will not be permitted. Fillers shall 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 shall 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 shall consist of a material that is compatible with the other components of the cable and shall be lapped at least 10 percent of its width.

#### 2.1.9 Dimensional Tolerance

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

#### 2.2 INSTALLATION INSTRUCTIONS

The following information shall 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 shall be provided for both the individual conductors and the multiple-conductor cable.
- b. Pulling tension and sidewall pressure limits, in poundsnewtons.
- 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 shall be stated. Also, if requested, recommendations shall be provided for various cable operations, including installing, splicing, terminating, etc.

#### 2.3 TESTS, INSPECTIONS, AND VERIFICATIONS

##### 2.3.1 Cable Data

Manufacture of the wire and cable shall not be started until all materials to be used in the fabrication of the finished wire or cable have been approved by the Contracting Officer. Cable data shall be submitted for approval including dimensioned sketches showing cable construction, and sufficient additional data to show that these specifications will be satisfied.

##### 2.3.2 Inspection and Tests

Inspection and tests of wire and cable furnished under these specifications shall be made by and at the plant of the manufacturer, and shall be witnessed by the Contracting Officer or his authorized representative, unless waived in writing. The Government may perform further tests before or after installation. Testing in general shall comply with Section 6 of NEMA WC 7 or Part 6 of NEMA WC 8. Specific tests required for particular materials, components, and completed cables shall be as specified in the sections of the above standards applicable to those materials, components, and cable types. Tests shall also be performed in accordance with the additional requirements specified below.

##### 2.3.2.1 High-Voltage Test Source

Where the applicable standards allow a choice, high-voltage tests for cables to be used exclusively on dc circuits shall be made with dc test voltages. Cables to be used exclusively on ac circuits shall 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 shall be used.

#### 2.3.2.2 Shielded Cables Rated 2,001 Volts or Greater

The following tests shall be performed in addition to those specified above. Section or paragraph references are to AEIC CS5 or AEIC CS6 as applicable, unless otherwise stated.

- a. High potential test voltages shall be as required by Table B1 of AEIC CS5 or AEIC CS6 as applicable, rather than by Table 3-1 of NEMA WC 7 or NEMA WC 8.
- b. If high potential testing is done with an ac test voltage as specified in paragraph HIGH-VOLTAGE TEST SOURCE, an additional test shall be made using a dc test voltage rated at 75 percent of the specified full dc test voltage, for 5 consecutive minutes.
- c. Production sampling tests shall be performed in accordance with Section D. Sampling frequency and failure contingencies shall be in accordance with paragraph G.3. Unless otherwise approved, samples shall not be taken from the middle of extruder runs of insulation or shielding made only for one continuous shipping length of cable, if such sampling will result in the need to repair the sampled area.
- d. Partial discharge tests shall be performed in accordance with Section E, paragraph E.2, and Section F.

#### 2.3.2.3 Flame Tests

All [multiple-conductor and single-conductor] cable assemblies shall pass IEEE Std 383 flame tests, paragraph 2.5, using the ribbon gas burner. Single-conductor cables and individual conductors of multiple-conductor cables shall pass the flame test of NEMA WC 7, paragraph 7.7.3.1.3. 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 shall be submitted. In this case the reports furnished under paragraph REPORTS, shall verify that all of each cable's materials, construction, and dimensions are the same as those in the qualifying tests.

#### 2.3.2.4 Independent Tests

The Government may at any time 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.

#### 2.3.2.5 Reports

Results of tests made shall be furnished. No wire or cable shall be shipped until authorized. Lot number and reel or coil number of wire and cable tested shall be indicated on the test reports.

### PART 3 EXECUTION (Not Applicable)

\*\*\*\*\*  
**ADDITIONAL NOTES**

**NOTE A: For Additional information on the use of  
all UFGS, see UFGS GENERAL NOTES.**

NOTE B: 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.

A. 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 (1003514r 133%).
- 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, give 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.

B. Quantities and Description of Cable.

- a. Total number of feetmeters, 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 mils micrometers. If conditions require other than standard stranding, a complete description should be

given.

f. Grade of insulation.

g. Thickness of insulation, in mils/micrometers.

h. Type of outer covering.

i. Maximum allowable overall diameter, in inches/millimeters. When duct space is not limited, it is not wise to restrict the overall diameter.

j. Method of conductor identification.

NOTE C: Conductors for wire and cable rated 2,000 volts or less shall be copper. For wire and cable rated 2,001 volts and above, the specifications may be written to permit either aluminum or copper conductors where aluminum is suitable for the application and is determined to be more economical than copper.

NOTE D: 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. Costs should be compared 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.

NOTE E: 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.

NOTE F: The insulation compounds specified herein are of the thermosetting type. Two options are included: cross-linked thermosetting polyethylene (XLPE), in accordance with the National Electrical Manufacturers Association (NEMA) publication WC 7 (Insulated Cable Engineers Association (ICEA) publication S-66-524), or ethylene-propylene rubber (EPR), in accordance with NEMA WC 8 (ICEA S-68-516).

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. The grades permitted are all 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.

NOTE G: 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 will not be permitted.

NOTE H: The following insulation thickness options from Table 3-1 of NEMA Standards WC 7 and WC 8 for single-conductor cables rated 2,000 volts and below have been specified: (1) Column A thickness, which does not require a jacket, may be used only for XLPE insulated cable. NEMA WC 8 allows Type II EPR to be used with Column A thickness without a jacket; however, this application should not be permitted because the Type II EPR insulation is significantly short of meeting jacket physical requirements. (2) Column B thickness may be used for either XLPE or EPR Type I or II insulated cable, but only with a jacket. For multiple-conductor cables, either Table 3-1 of NEMA WC 7 or WC 8 may be followed, or if applicable, Section 7.7 of NEMA WC 7 or Part 7.5 of NEMA WC 8.

NOTE I: All cable assemblies (multiple-conductor and single-conductor) shall pass, or be capable of passing, the Institute of Electrical and Electronics Engineers (IEEE) 383 flame test, paragraph 2.5,

using the ribbon gas burner. Single conductors and individual conductors of multiple-conductor cables shall also be required to pass the flame test described in NEMA WC 7, paragraph 7.7.3.1.3. (This 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.)

NOTE J: 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 paragraph TESTS, INSPECTIONS, AND VERIFICATIONS, 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. When the wire and cable must meet IEEE Std 383, the reports required in paragraph TESTS, INSPECTIONS, AND VERIFICATIONS, subparagraph FLAME TESTS, should always be submitted. 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.

NOTE K: 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.

NOTE L: Example Typical Wire Table:

---

WIRE TABLE



Item No.	Size, AWG or kcmil	No. of Conds.	Rated Circuit Voltage	Stranding	Comments	Quantity lin ftmeters
1	12	1	600	B or C	General use	3,260
2	12	1	600	* Solid	Lighting	960
3	10	4	1,000	B or C	Current transformers	120
4	2/0	3	15 kV	B or C	Shield, armor, jacket	275
.....						
17	12	9	1,000	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 footmeter, or if they are stated to be approximate, subject to contractor verification.

\*\*\*\*\*

---

WIRE TABLE

[illegible]

Class \_\_\_\_ stranding may be substituted for \_\_\_\_ where indicated by "\*".

```
-- End of Section --
```