



NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing

Washington Metropolitan Area Transit Authority Metrorail train 302 that encountered heavy smoke in the tunnel between the L'Enfant Plaza Station and the Potomac River Bridge on January 12, 2015

GROUP	C
EXHIBIT	
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Agency / Organization

WMATA

Title

**Section 1602 – Wire, Cable and Busways
Specifications**

Section 1602

WIRE, CABLE AND BUSWAYS

Substitute the following in lieu of the Standard Specification Section 1602.

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section specifies furnishing and installing wires and cables.

B. Related Work Specified Elsewhere:

1. Bonding for stray current: Section 1605.
2. Conduit, raceways, boxes and cabinets: Section 1601.
3. Connectors, insulating tape and resin: Section 1603.

1.2 QUALITY ASSURANCE:

A. Reference Codes, Regulations, and Standards:

1. Codes and regulations of jurisdictional authorities.
2. National Electrical Code.
3. Reference standards: ANSI, NEMA, ICEA, IEEE, ASTM, and UL, as specified.

B. Source Quality Control:

1. Conductors, insulation and jacket materials to comply with pertinent parts of specified standards.

1.3 SUBMITTALS:

A. Submit in accordance with the General Requirements:

1. Shop drawings and manufacturer's literature.
 - a. Manufacturer's literature shall include parts list and outline/assembly drawings.

2. Samples, certificates and test reports:

a. Submit flame retardancy and smoke density test reports and data for tests performed not more than 12 months prior to the submittal, for materials which are identical to those of the finished cable.

b. Provide certified test reports demonstrating that the cable complies in all respects with the requirements of the referenced ICEA Standards as modified herein.

c. Provide certificate of conformance to all specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

3. Smoke density test sample: The specified sample will become the property of the Authority.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Marking provided on each single-conductor cable and multiple-conductor cable to show UL label, size, voltage, manufacturer and number of conductors or phases.

B. Ship each unit securely wrapped, packaged, and labeled for safe handling and shipment.

C. Store products in a dry and secure facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

A. General Requirements for Single-Conductor and Multiple-Conductor Cable:

1. Type and size: As shown.

2. Rated voltage: 600 volts.

3. Conductors: Copper, solid and stranded.

a. Size 10AWG and smaller: Solid or Class B or Class C stranded.

b. Size 8AWG and larger: Class B stranded.

4. Standards: Except as modified, all wires and cable complying in all respects with the following standards:

a. For cross-linked polyethylene insulated cable: ICEA S-66-524, NEMA WC7.

b. For all other cables: ICEA S-68-516, NEMA WC8.

5. Nonmetallic jacket: Chlorosulfonated polyethylene or cross-linked polyolefin, as follows:

a. Chlorosulfonated polyethylene complying in all respects with paragraph 4.4.9 of ICEA S-68-516, NEMA WC-8. Jacket material free of PVC and PVC-based compounds.

b. Cross-linked polyolefin complying with the following physical requirements. These properties shall be tested in accordance with Part 6 of ICEA S-68-516, NEMA WC8 if ethylene-propylene-rubber insulation is used, or with Part 6 of ICEA S-66-524, NEMA WC7 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.

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| (1) Tensile strength, minimum pounds per square inch. | 1800 |
| (2) Elongation at rupture, minimum percent | 150 |
| (3) Aging requirement:
After 168 hours in air oven test at 100C, plus or minus one degree C: | |
| (a) Tensile strength, minimum percentage of unaged value | 100 |
| (b) Elongation at rupture, minimum percentage of unaged value | 80 |
| (4) Oil immersion: 18 hours at 121C, plus or minus one degree C, ASTM D471, Table 1, No. 2 oil: | |
| (a) Tensile strength, minimum percentage of unaged value | 80 |
| (b) Elongation at rupture, minimum percentage of | |

6. Flame retardancy: All single-conductor and multiple-conductor cable demonstrating flame retardancy as described in IEEE 383.

a. Single-conductor cable and individual conductors of multiple-conductor cable passing the vertical flame test. Cable size for testing: 14AWG.

b. Single-conductor cable and individual conductors of multiple-conductor cable, of Size 250 MCM and larger, passing the vertical tray flame test, using a gas burner. Cable size for testing: 250 MCM.

c. Multiple-conductor cable passing the vertical tray flame test, using a gas burner. Cable size for testing: 7/C or 9/C with 12AWG or 14AWG conductors.

7. Smoke generation: All single-and multiple-conductor cable jacket materials demonstrating low smoke generation when tested in accordance with ASTM E662 by an independent nationally recognized testing agency.

a. Conduct tests on specimens of the overall jacket material for multiple-conductor cable and of the jacket material for single-conductor cable.

b. Prepare slab specimens for each material .100 inch, plus or minus .005 inch thick, identical to those of the finished cables and meeting the minimum physical requirements specified.

(1) Prior to testing, submit a six-inch square portion of each specimen to the Engineer. Tag sample with the manufacturer's jacket or insulation identification code or number.

c. Test values for chlorosulfonated polyethylene not to exceed the following:

(1) Flaming mode:

(a) Uncorrected maximum specific optical density during first four minutes of test: 325.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 400.

(2) Non-flaming mode:

(a) Uncorrected maximum specific optical density during first four minutes of test: 325.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 480.

d. Test values for cross-linked polyolefin not to exceed the following:

(1) Flaming mode:

(a) Uncorrected maximum specific optical density during first four minutes of test: 150.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

(2) Non-flaming mode:

(a) Uncorrected maximum specific optical density during first four minutes of test: 150.

(b) Uncorrected maximum specific optical density for entire 20-minute test: 300.

8. Applied voltage testing:

a. All single-conductor cable and all individual conductors of multiple-conductor cable to be given an applied ac voltage dielectric strength test, i.e., six-hour-water-immersion test.

b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

c. Test procedures:

(1) For polyethylene insulated conductors: In accordance with paragraphs 6.14.1, 6.14.2, 6.14.5, and 3.5.2 of ICEA S-66-524.

(2) For all other conductors: In accordance with paragraphs 3.5.2, 6.27.1, and 6.27.2 of ICEA S-68-516.

B. Single-Conductor Cable:

1. UL-labeled as Type RHW.

2. Insulated with ethylene-propylene-rubber only and provided with nonmetallic jacket as specified.

3. Color coding: In accordance with paragraphs 200-6, 200-7, and 210-5 of the NEC.

C. Multiple-Conductor Cable:

1. Individual conductors:

a. Number of conductors: As shown.

b. Construction: Complying with any one of the following:

(1) Insulated with ethylene-propylene-rubber, with or without nonmetallic jacket as specified.

(2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, UL Class EPCV.

(3) Insulated with filled cross-linked polyethylene.

c. Phase and neutral conductors: Individually insulated.

d. Neutral conductors: Same size as phase conductors.

e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.

f. UL-labeled as Type RHW or XHHW.

2. All conductors assembled with a non-wicking, flame-retardant filler to form a cable of circular cross section.

3. Metallic-sheathed cable to be provided with interlocked aluminum tape armor or continuous aluminum sheath for 2AWG and smaller, with interlocked aluminum tape armor for 1AWG and larger. Metallic covering not required for multiple-conductor cable with overall nonmetallic jacket for Type TC cable when installed in cable tray.

4. All multiple-conductor cable provided with overall nonmetallic jacket, as specified.

5. Cable UL-labeled as follows:

a. Non-metallic sheathed cable: Type TC, suitable for wet and dry locations.

b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.

6. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

D. Fixture Wire: UL 62, with the following additional requirements:

1. Type: SF-2 silicone rubber-insulated or as required to suit temperature rating of lighting fixture, minimum 90C.

2. Conductor: Stranded copper conductor 16AWG or larger as shown.

E. Bare Conductor: ANSI C7.1 or ASTM B3, Class B stranded annealed copper conductor unless otherwise shown, size as shown.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install single-conductor cable in conduit or approved raceway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 1601. On walls or ceilings, fasten cable and bus duct directly to embedded inserts, or use expansion bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry walls. Splice cable only when unavoidable.

B. Install motor feeders, service connections and extensions in accordance with the requirements of the referenced codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit, at motor conduit box.

C. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers, and switch-gears.

D. Use a minimum bending radius of not less than 12 times the outer diameter of the cable. Where shown, use shorter bending radius as permitted by NEC, Appendix H of ICEA S-66-524, NEMA WC7, and cable manufacturer.

E. To facilitate pulling cable, use UL-listed lubricant recommended

by cable manufacturer.

H. In damp and dusty indoor locations, manholes, and outdoor locations, seal cable at conduit termination using a duct sealing compound.

I. Where shown or required, install cable seal fitting specified in Section 1601 to prevent entry of water into electrical facilities.

3.2 IDENTIFICATION:

A. Identify cable terminations, feeders, and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown.

3.3 FIELD QUALITY CONTROL:

A. Furnish equipment required to perform tests. Prior to insulation and high potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct all tests in the presence of the Engineer.

B. Submit for approval a test procedure and perform approved tests including, but not limited to, the following:

1. Single-conductor cable and multiple-conductor cable:

a. Test continuity of cable conductors using ohmmeter.

b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1000-volt megger. Insulation resistance not less than 100,000 ohms.

c. When cable shows unsteady insulation resistance or less than 100,000 ohms, perform high potential test at 80 percent of factory ac test voltage or as recommended by cable manufacturer.

C. Submit certified test reports.

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