NEMA RV 2

Application and Installation Guidelines for Nonmetallic-Sheathed Cable and Underground Feeder and Branch Circuit Cable

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Application and Installation Guidelines for Nonmetallic-Sheathed Cable and Underground Feeder and Branch Circuit Cable

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Foreword

These application and installation guidelines offer practical information on correct usage and industry recommended practices for the installation of Type UF-B underground feeder cable in accordance with the *National Electrical Code*®.

These guidelines have been developed by the NEMA Building Wire and Cable Section, which has committed to periodically reviewing them for any revisions necessary to address changing conditions, product listing and installation requirements, and technical progress. Comments for proposed revisions are welcomed and should be submitted to:

Vice President, Technical Services
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

At the time of approval, the Building Wire and Cable Section of the National Electrical Manufacturers Association had the following members:

AFC Cable Systems—New Bedford, MA
Alcan Cable—Atlanta, GA
Alflex Corporation—Long Beach, CA
Amercable—El Dorado, AR
American Insulated Wire Corporation—Pawtucket, RI
Colonial Wire & Cable, Inc.—Hauppauge, NY
Encore Wire Corporation—McKinney, TX
Essex Electric, Inc.—Fort Wayne, IN
General Cable—Highland Heights, KY
Nexans Canada, Inc.—Chester, NY
Service Wire Corporation—Culloden, WV
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The Okonite Company—Ramsey, NJ
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Section 1
APPLICATION GUIDELINES FOR NONMETALLIC-SHEATHED CABLE

1.1 CONSTRUCTION

1.1.1 General

Nonmetallic-Sheathed Cable (NM Cable, to be referred to throughout these guidelines as Type NM-B) constructed in accordance with the *National Electrical Code*® (*NEC*) employs copper, copper-clad, or recognized AA-8000 aluminum alloy conductors. Type NM-B can be found in either flat or round constructions.

Copper conductors are of sizes 14–2 AWG. Copper-clad or aluminum conductors are of sizes 12–2 AWG. The *NEC*® recognizes three cable types—Types NM-B, NMC, and NMS. Currently, Types NMC and NMS are not commercially available, but Type UF-B can be substituted for NMC. Type NMS is a construction consisting of NM-B and data/communication cables.

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1.1.2 Circuit Conductors

All circuit conductors 8 AWG and larger are stranded. Circuit conductors of Type NM-B typically have dry-location polyvinyl chloride (PVC)/nylon insulation. These comply with UL 83 requirements for THHN but are not marked as such, and cannot be used as THHN wires.

1.1.3 Grounding Conductor

Where a grounding conductor is present, it will always be in one location in the cable. In flat Type NM-B, it is located either in the valley between the circuit conductors or directly between them. In a twisted construction the grounding conductor may be wound along with the circuit conductors or in the center of the assembly. Bare grounding conductors are wrapped in paper to prevent contact with the nylon jacketing or circuit conductor insulation.

The permitted sizes of grounding conductors for Type NM-B are summarized in Table 1.

1.1.4 Cable Sheath

The sheath of listed NM-B is made to provide flexibility and resistance to abrasion. Physical properties tests in UL 719 are conducted to evaluate these properties. Typically, PVC is the material used.

Table 1
GROUNDING CONDUCTORS IN NM-B CABLES WITH 2, 3, OR 4 CIRCUIT CONDUCTORS

Size of Circuit Conductors	Smallest Acceptable Grounding Conductor
14	14 AWG
12	12
10, 8, 6	10
4	8
3, 2	8

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1.2 GROUNDING

A grounding conductor connects the non-current carrying metal parts of equipment to the grounded conductor. For example, metal outlet boxes are connected by grounding conductors to the grounded bar in the service panel. The grounding conductor in Type NM-B Cable is typically bare but can also be insulated green.

1.3 MARKING AND IDENTIFICATION

1.3.1 Finished Cable

The surface of the finished cable will include the type designation, the AWG size and number of conductors, and the voltage rating, which for NM-B is 600 V. The surface might have additional markings indicating suitability for a given application. Package markings also accompany the finished cable either in the form of shrink-wrap, cartons or labeled reels, depending on customer needs.

1.3.2 Grounding Conductors

Grounding conductors are bare, or in the case of 3-conductor cable, may be green-insulated.

1.3.3 Size Identification

Although there are no requirements specifying jacket color for a given size cable, the use of the following jacket colors are widespread throughout the industry:

White: 14 AWG
Yellow: 12 AWG
Orange: 10 AWG
Black: 8 AWG and larger

1.4 CODES AND STANDARDS

1.4.1 *National Electrical Code*®

Type NM-B Cable is listed in accordance with UL 719, and designed, manufactured, and tested for use in accordance with the *2002 National Electrical Code*® Article 334.

1.4.1.1 Uses permitted

Type NM-B cable is permitted for both exposed and concealed work in normally dry locations except as prohibited by the *NEC*®, and may be installed or fished in air voids in masonry block or tile walls.

Type NM-B is permitted for use in one- and two-family dwellings. It is also permitted in multifamily dwellings, which are Types III, IV, and V construction, as defined in NFPA 220-1999, *Standard on Types of Building Construction*, except where the *NEC*® specifically prohibits its use. Annex E of the NEC® also includes the definitions of the construction types. Use of Type NM-B in multifamily and other structures is restricted to buildings of 5 stories or less.

Nonmetallic-Sheathed Cable, when used in structures other than dwellings, must be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating, as identified in listings of fire resistance rated assemblies.

NM-B is also permitted for use in cable trays, if identified for that use, but are subject to temperature limitations of the conductors. Presently, NM-B for this application is not commercially available.

1.4.1.2 Additional permitted uses of Type NM Cable

Type NMC – Although Type NMC is not commercially available, Type UF-B can be used as a substitute and can be installed in both exposed and concealed work in dry, moist, damp, or corrosive locations, except as prohibited by the *NEC*®, as well as outside and inside walls of masonry block or tile, and in a

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shallow chase in masonry, concrete, or adobe as long as it is protected against nails or screws by a steel plate at least 1.59 mm (1/16 in.) thick and covered with plaster, adobe, or similar finish.

Type NMS – Currently, Type NMS cable is not commercially available. It is a construction consisting of NM-B and data/communication cables.

1.4.1.3 Uses Not Permitted

Type NM-B cable is prohibited in the following applications:

- As open runs in drop or suspended ceilings in other than one- and two-family and multifamily dwellings.
- For use as service-entrance cable.
- Commercial garages having hazardous (classified) locations as defined in 511.3.
- Theaters and similar locations, except where permitted in 518.4.
- Motion picture studios.
- Storage battery rooms.
- Hoistways or on elevators or escalators.
- Embedded in poured cement, concrete, or aggregate.
- Hazardous (classified) locations, except as permitted in Sections 501.4(B)(3), 502.4(B)(3) and 504.20.
- Where exposed to corrosive fumes or vapors.
- Where embedded in masonry, concrete, adobe, fill, or plaster.
- In a shallow chase in masonry, concrete, or adobe, where covered with plaster, adobe, or similar finish.
- Where exposed or subject to excessive moisture or dampness.

1.4.1.4 Related *NEC*® Articles

The following *NEC*® Articles also contain provisions for the use of Type NM:

Wiring and Protection

250.86 Other Conductor Enclosures and Raceways

Wiring Methods and Materials

Article 300 – Wiring Methods

300.4 Protection Against Physical Damage
300.15 Boxes Conduit Bodies, or Fittings—where Required
300.16. Raceway or Cable to Open or Concealed Wiring

Article 310 – Conductors

310.11. Marking
310.13 Conductor Constructions and Applications

Article 314 – Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Manholes

314.17 Conductors entering Boxes, Conduit Bodies or Fittings

Article 334 – Nonmetallic-Sheathed Cable: Types NM, NMC, and NMS

392.3 Uses Permitted

Equipment for General Use

Article 410 – Lighting Fixtures, Lampholders, Lamps, and Receptacles

410.14. Connection of Electric-Discharge Lighting Fixtures

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Special Occupancies

Article 518 – Places of Assembly
518.4. Wiring Methods

Article 520 – Theaters, Audience Areas of Motion Picture and TV Studios, and Similar Locations
520.5(c) Wiring Methods

Article 550 – Mobile Homes, Manufactured Homes, and Mobile Home Parks
550.15 Wiring Methods and Materials

Article 551 – Recreational Vehicles and Recreational Vehicle Parks
551.10 Low Voltage Systems
551.47 Wiring Methods
551.55(c) Interior Equipment Grounding

Article 552 – Park Trailers
552.10 Low Voltage Systems
552.48 Wiring Methods
552-56 Interior Equipment Grounding

Special Conditions

Article 725 – Class 1, Class 2, and Class 3 Remote-Control Signaling, and Power-Limited Circuits
725.55 Separation from Electric Light, Power, Class 1, NPLFA Circuit Conductors, and Medium Power Network-Powered Broadband Communication Cables
725.71 Listing and Marking of Class 2, Class 3, and Type PLTC Cables
760.55 Separation from Electric Light, Power, Class 1, NPLFA, and Medium Power Network-Powered Broadband Communications Circuit Conductors

Communications Systems

Article 800 – Communications Circuitry
800.133 Installation of Communications Wires, Cables, and Equipment

Article 830 – Network Powered Broadband Communications Systems
800.133 Installation of Network-Powered Broadband Communications, Cables, and Equipment

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1.4.2 Underwriters Laboratories Inc. (UL) Standards and Directories

UL publishes a number of standards and directories that provides detailed information on the construction, performance, application, ratings, and installation aspects of Type NM-B cable.

1.4.2.1 Standards

The UL standard for the construction and performance of Type NM-B cable is UL 719. According to *NEC*® Section 334.112, the insulated conductors for NM-B cable must be of the types listed in Table 310.13, or one identified for use in this cable. Currently all Type NM-B cable contains THHN-style conductors. TW style conductors have been used in the past, and are permitted by UL 719, but are not presently used.

1.4.2.2 Directories

UL publishes several directories that contain useful information on the products that it lists, recognizes, and certifies. Installers and inspection authorities use these directories frequently to gain a better

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understanding of how to specify and install products in accordance with their listing, and to demonstrate that a product is UL Listed.

These directories are helpful tools for understanding the details of how products, in this case Type NM-B cable, are constructed and marked as well as information on special or optional ratings, and terminations. One of the directories covers the UL approved methods for maintaining the fire resistive rating on walls, floors, and ceilings for fire-resistance rated construction, when cables must penetrate them and be fire stopped.

1. *UL General Information for Electrical Equipment Directory – White Book*

The following information on Type NM Cable is reprinted from the *UL General Information for Electrical Equipment Directory*, with permission from Underwriters Laboratories Inc., © Copyright 2003 Underwriters Laboratories Inc.

Types NM-B and NMC-B Nonmetallic-Sheathed Cables, rated 600 volts, intended for use in accordance with Article 334 of the *National Electrical Code*, are Listed in copper sizes 14 to 2 AWG inclusive and aluminum or copper clad aluminum sizes 12 to 2 AWG inclusive.

These cables contain conductors rated 90C, however, the ampacities of the cables are those of 60C conductors as specified in Article 334 and Table 310.16 of the National Electrical Code.

Cables with copper-clad aluminum conductors are surface marked “AL (CU-CLAD)” or “Cu-clad Al,” and cables with aluminum conductors are surface marked “AL.”

Wires and cables employing compact stranded copper conductors are so identified directly following the conductor size, wherever it appears (surface, tag, carton or reel), by compact “compact copper.” Abbreviations of “CMPCT” and “CU” may be used for compact and copper, respectively.

Tags, reels, and cartons for products employing compact-stranded copper conductors have the following marking: “Terminate with connectors identified for use with compact-stranded copper conductors.”

For termination information see Guide AALZ information.

Cables that are suitable for use in cable trays are appropriately marked. Cables marked for cable tray use may also have a supplementary sunlight resistant marking.

Cables that comply with the Limited Smoke Test requirements specified in UL 1685, *Standard Vertical Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables*, are surface marked with a suffix “LS.”

The basic standard used to investigate products in this category is UL 719, *Nonmetallic-Sheathed Cables.*

The UL symbol on the product and the Listing Mark of Underwriters Laboratories Inc. on the attached tag, coil, reel, or smallest unit container in which the product is packaged is the only method provided by UL to identify these products manufactured under its Listing and Follow-Up Service. The Listing Mark for these products includes the name and/or symbol of Underwriters Laboratories Inc. (as illustrated in the Introduction of this directory) together with the word “Listed,” a control number, and the following product name as appropriate: A non metallic sheathed cable that contains copper or copper-clad aluminum conductors has the product name “Nonmetallic Sheathed Cable”; a nonmetallic sheathed cable that contains aluminum conductors has the product name “Nonmetallic-Sheathed Aluminum Cable.”

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2. *UL Electrical Construction Equipment Directory – Green Book*

UL's *Electrical Construction Equipment Directory, Green Book*, contains the identical information that is contained in the White Book with the addition of the company name, address, and UL file number of those manufacturers that are authorized by Underwriters Laboratories to produce a listed product. The *Green Book* is frequently used to identify and locate listed manufacturers of Type NM Cable, to verify if a manufacturer is authorized to produce UL Listed Type NM, and to identify the manufacturer of the cable when the cable is marked with the UL File number (E number) in place of the company name. *Green Book* information on Type NM Cable (category code PWVX) can be found here.

3. *UL Fire Resistance Directory – Orange Book*

UL's *Fire Resistance Directory, Orange Book*, generally covers the construction detail necessary for constructing fire rated walls, floors, and ceilings. The *Directory* also covers the Listed materials and methods for sealing the wall ceiling or floor that has been penetrated by electrical cables, conduit, cable tray or other equipment. The methods and materials are Listed by UL under the category of "Through Penetration Fire Stop Systems." The *Directory* should always be consulted for the proper method of sealing the opening. Any such opening that is not properly sealed in accordance with the UL Listed "Through Penetration Fire Stop Systems" will be subject to rejection by the inspecting authority. A complete list of fire resistive ratings in accordance with UL 263 can be found here.

4. UL Listing on Web Site

UL operates a web site at www.ul.com. This web site contains an online version of the above directories as well as other general information relating to UL's products and services.

Once logged onto the UL web site, go to the UL online certification directory. This will lead you to a list of product categories. The following list or one similar will be presented:

- UL File Number
- Appliance Wiring Material (AWM)
- Fire Resistance - Design or System Number
- Roofing Materials & Systems - Construction Number
- Building Materials - Assembly Number
- UL Category Control Number (CCN)/Guide Information
- Keyword Search

The category should be chosen based on the information available to you. The "Key Word" search is the easiest way to start if limited information is available. As an example, using "NM-B" as the key word opens the path to the list of manufacturers of Type NM-B cable and to information covered by the UL *Green* and *White Book* directories.

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Section 2
APPLICATION GUIDELINES FOR UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE

2.1 CONSTRUCTION

2.1.1 General

The *National Electrical Code*® recognizes one type of underground feeder and branch circuit cable – Type UF. Multiconductor cables are identified as UF-B, indicating that the circuit conductors are rated 90ºC dry and at least 60ºC wet, and that the jacket is rated at least 75ºC. The ampacity of these cables is that of 60ºC rated conductors. Type UF cables are a flat construction.

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2.1.2 Circuit Conductors

All circuit conductors 8 AWG and larger are stranded. Circuit conductors of Type UF-B have wet-location polyvinyl chloride (PVC)/nylon insulation. These comply with UL 83 requirements for THWN but are not marked as such, and cannot be used as THWN wires.

Type UF-B cables employ copper, aluminum, or copper-clad aluminum conductors. The size range of copper conductors is 14–6 AWG. Aluminum or copper-clad aluminum conductors range from 12–6 AWG. The insulation material is always a moisture-resistant material and suitable for branch circuit wiring, or another material that is identified for branch circuit applications.

2.1.3 Grounding Conductors

Type UF-B cable typically incorporates a bare grounding conductor for equipment grounding purposes. Where a grounding conductor is present, it will always be in one location in the cable, located in the valley between the circuit conductors but not directly between them.

The permitted sizes of grounding conductors for Type UF-B are summarized in Table 2.

Table 2
GROUNDING CONDUCTORS IN UF-B CABLES WITH 2, 3, OR 4 CIRCUIT CONDUCTORS

Size of Circuit Conductors	Smallest Acceptable Grounding Conductor
14	14 AWG
12	12
10	10
8, 6	10

2.1.4 Cable Sheath

The sheath of Type UF-B cable is always made of a flame retardant, moisture-, fungus-, corrosion, and sunlight-resistant material, and suitable for direct burial in earth.

2.2 GROUNDING

A grounding conductor connects the non-current carrying metal parts of equipment to the grounded conductor. For example, metal outlet boxes are connected by grounding conductors to the grounded bar in the service panel. The grounding conductor in Type UF-B Cable is typically bare but can also be insulated green.

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2.3 MARKING AND IDENTIFICATION

2.3.1 Finished Cable

The surface of the finished cable will include the type designation, the AWG size and number of conductors and the voltage rating, which for UF-B is 600 V. The surface might have additional markings indicating suitability for a given application, such as "Submersible Pump Cable." The jacket of UF-B cable is commonly marked "Sunlight Resistant," in accordance with UL 493, *Underground Feeder and Branch Circuit Cables*. Package markings also accompany the finished cable either in the form of shrink-wrap, cartons, or labeled reels, depending on customer needs.

2.3.2 Grounding Conductors

Grounding conductors are bare or may be green-insulated.

2.3.3 Jacket Color

There are no requirements specifying jacket color for any given size cable. Throughout the industry, the jacket is colored gray.

2.4 CODES AND STANDARDS

2.4.1 National Electrical Code®

Type UF-B cable is designed, manufactured and tested for use in accordance with the National Electrical Code Article 340. NEC Section 340.6 requires that Type UF-B Cable be listed.

2.4.1.1 Uses permitted

Type UF-B cable is permitted for use underground including direct burial in earth in accordance with NEC Section 300.5; for wiring in wet, dry or corrosive locations; installed as nonmetallic-sheathed cable as a multiconductor cable, in accordance with Article 334 subject to the conductor temperature limitations in Section 310.10; in solar photovoltaic systems in accordance with NEC Section 690.31; and in cable trays as a multiconductor construction.

2.4.1.2 Uses not permitted

Type UF-B cable is not permitted for use as a service-entrance cable, nor for commercial garage, theater, motion picture studio, storage battery room, hoistway, elevator, escalator, or hazardous location, applications.

UF-B cannot be exposed to direct sun unless it is has been identified as "Sunlight resistant." UF-B is also prohibited where it would be subject to physical damage, or in poured cement, concrete, or aggregate except when it is embedded in plaster when serving as non-heating leads according to Section 424.43.

Type UF Cable cannot be used as overhead cable unless installed as messenger-supported wiring in accordance with NEC Article 396.

2.4.1.3 Additional information on the use of UF Cables

2.4.1.3.1 Bending Radius.

Bends in Type UF cable must be made in a way that the cable will not be damaged. The radius of the curve of the inner edge of any bend must be less than five times the diameter of the cable (See NEC Section 340.24).

2.4.1.3.2 Ampacity

The ampacities of Type UF-B cables are determined according to NEC Section 310.15, in accordance with the 60ºC (140ºF) conductor temperature rating. The 90ºC (194ºF) rating is permitted for ampacity derating purposes provided the final derated ampacity does not exceed that for a 60ºC rated conductor.

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2.4.1.4 Related NEC Articles

The following NEC Articles also contain provisions for the use of Type UF:

Wiring Methods and Materials

- 310.11. Marking
- 310.13 Conductor Constructions and Applications
- 314.17 Conductors Entering Boxes, Conduit Bodies or Fittings
- ARTICLE 340 -- Underground Feeder and Branch Circuit Cable: Type UF
- 392.3 Uses Permitted
- 396.10 Messenger supported wiring. Uses permitted.

Special Occupancies

- ARTICLE 551 -- Recreational Vehicles and Recreational Vehicle Parks
- 551.47 Wiring Methods
- 551.80 Underground Service Feeder, Branch Circuit and Recreational Vehicle Site Feeder-circuit Conductors
- ARTICLE 552 -- Park Trailers
- 552.10 Low Voltage Systems
- 552.48 Wiring Methods

Special Conditions

- ARTICLE 725 – Class 1, Class 2, and Class 3 Remote-Control Signaling, and Power-Limited Circuits
- 725.55 Separation from electric light, Power, Class 1, Non-Power-Limited Fire alarm Circuit Conductors
- 760.55 Separation from Electric Light, Power, Class 1, NPLFA, and Medium Power Network-Powered Broadband Communications Circuit Conductors

Communications Systems

- ARTICLE 800 Communications Circuits
- 800.133 Installation of Communications Wires, Cables, and Equipment
- ARTICLE 830 Network Powered Broadband Communications Systems
- 830.133 Installation of Network-Powered Broadband Communications, Cables, and Equipment

Annex

- Annex A
- Annex F

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2.4.2 UL Standards and Directories

UL publishes a number of standards and directories that provides detailed information on the construction, performance, application, ratings, and installation aspects of Type UF-B cable. Underwriters Laboratories Inc. publishes a number of Standards and Directories that provides detailed information on the construction, performance, application, ratings, and installation aspects of Type UF-B cable.

2.4.2.1 UL Standards

The UL Standard for the construction and performance of Type UF-B cable is UL 493. According to NEC Section 340.112, the insulated conductors for UF-B cable must be of the moisture-resistant types listed in Table 310.13, that is suitable for branch-circuit wiring or one identified for use in this cable. All Type UF-B cable contains Type THWN conductors. Insulation types however, are allowed to be THWN, THWN-2, or

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TW covered in UL 83. TW style conductors have been used in the past, and are permitted by UL 493, but are not presently used.

2.4.2.2 UL Directories

UL publishes several Directories that contain useful information on the products that it Lists, Recognizes, and Certifies. The Directories are frequently used by installers and by inspection authorities to gain a better understanding of how to specify and install products in accordance with their Listing, and to demonstrate that a product is Listed by Underwriters Laboratories.

These Directories are helpful tools for understanding the details of how products, in this case Type UF-B Cable, are constructed and marked as well as information on special or optional ratings, and terminations. One of the Directories covers the UL approved methods for maintaining the Fire Resistive rating on walls, floors, and ceilings for fire-resistance rated construction, when cables must penetrate them and be fire stopped.

1. UL General Information for Electrical Equipment Directory-White Book

The following information on Type UF Cable is extracted from the UL General Information for Electrical Equipment Directory-White Book:

> *Underground Feeder and branch circuit cable, rated 600 volts, is Listed in copper sizes 14 to 4/0 AWG inclusive and aluminum or copper clad aluminum sizes 12 to 4/0 AWG inclusive for single and multiple conductor cables. It is designated as Type UF cable and is intended for use in accordance with Article 340 of the National Electrical Code®, NFPA-70.*
>
> *Some multiconductor cable is surface marked with the suffix "B" immediately following the type letters to indicate the usage of conductors employing 90ºC rated insulation. Such cables may also be installed as Non Metallic-Sheathed Cable, per section 340.10(4) of the National Electrical Code. The ampacities of Type UF cable, with, or without the suffix "B," are those of 60ºC rated conductors as specified in the latest edition of the National Electrical Code®.*
>
> *Submersible Water Pump Cable–Indicates a multiconductor cable in which 2,3, or 4 single- conductor type UF cables are provided in a flat or twisted assembly. The cable is Listed in sizes from 14 AWG to 4/0 AWG inclusive, copper, and from 12 AWG to 4/0 AWG inclusive, aluminum or copper clad aluminum. The cable is tag marked "For use within the well casing for wiring deep well water pumps where the cable is not subject to repetitive handling caused by frequent servicing of the pump units." The insulation may also be surface-marked "Pump Cable." The cable may be directly buried in the earth in conjunction with this use.*
>
> *Cables employing compact stranded copper conductors are so identified directly following the conductor size, wherever it appears (surface, tag, carton or reel), by compact "compact copper." Abbreviations of "CMPCT" and "CU" may be used for compact and copper, respectively.*
>
> *Tags, reels, and cartons for product employing compact-stranded copper conductors has the following marking: "Terminate with connectors identified for use with compact-stranded copper conductors."*
>
> *Pump cable, Submersible Water.*
>
> *For termination information see Guide AALZ information.*
>
> *This cable may be terminated at boxes and other enclosures by using nonmetallic-sheathed cable connectors (see Nonmetallic-sheathed Cable Connectors, PXJV).*
>
> *Cables suitable for exposure to direct rays of the sun are indicated by tag marking and marking on the surface of the cable with the designation "Sunlight Resistant."*
>
> *The basic standard used to investigate products in this category is UL 493, Thermoplastic–Insulated and Underground Feeder and Branch-circuit Cables.*
>
> *The UL symbol on the product and the Listing Mark of Underwriters Laboratories Inc. on the attached tag, coil, reel or smallest unit container in which the product is packaged is the only method provided by UL to identify these products manufactured under its Listing and Follow-Up Service. The Listing Mark for these products includes the name and/or symbol of Underwriters Laboratories Inc. (as illustrated in the Introduction of this directory) together with the word "Listed," a control number, and the following product name as appropriate: An underground feeder cable that contains copper or copper-clad aluminum*

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conductors has the product name "Underground Feeder Cable," an underground feeder cable that contains aluminum conductor has the product name "Aluminum Underground feeder Cable"

2. UL Electrical Construction Equipment Directory – Green Book

UL's Electrical Construction Equipment Directory, Green Book, contains the identical information that is contained in the White Book with the addition of the Company Name, Address, and UL File number of those manufacturers that are authorized by Underwriters Laboratories to produce a Listed product. The Green Book is frequently used to identify and locate Listed manufacturers of Type UF cable, to verify if a manufacturer is authorized to produce UL Listed Type UF, and to identify the manufacturer of the cable when the cable is marked with the UL File number (E number) in place of the company name.

3. UL Fire Resistance Directory – Orange Book

UL's Fire Resistance Directory, Orange Book, generally covers the construction detail necessary for constructing fire rated walls, floors, and ceilings. The Directory also covers the Listed materials and methods for sealing the wall ceiling or floor that has been penetrated by electrical cables, conduit, cable tray or other equipment. The methods and materials are Listed by UL under the category of Through Penetration Fire Stop Systems. The Directory should always be consulted for the proper method of sealing the opening. Any such opening that is not properly sealed in accordance with the UL Listed Through Penetration Fire Stop Systems will be subject to rejection by the inspecting authority.

4. UL Listing on Web Site

Underwriters Laboratories operates a web site at www.ul.com. This site contains an online version of the above Directories as well as other general information relating to UL's products and services.

Once logged onto the UL web site go to UL online certification directory this will lead you to a list of product categories. The following list or one similar will be presented.

- Company Name/Location
- UL File Number
- Appliance Wiring Material (AWM)
- Fire Resistance - Design or System Number
- Roofing Materials & Systems - Construction Number
- Building Materials - Assembly Number
- UL Category Control Number (CCN)/Guide Information
- Keyword Search

The category should be chosen based on the information available to you. The Key Word search is the easiest way to start if limited information is available. As an example, using "Underground Feeder Cable" as the Key Word opens the path to the information covered by the UL "Green" and "White" Book Directories.

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Section 3
INSTALLATION GUIDELINES FOR NONMETALLIC-SHEATHED CABLE AND UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE

3.1 GENERAL

Nonmetallic-Sheathed and Underground Feeder cables are permitted in both metallic and nonmetallic outlet boxes. Assembly of an NM-B or UF-B cable and fitting system can be achieved, and optimum performance ensured, by adherence to the following simple cable preparation and assembly techniques:

- ❑ Securely attach the cable fitting to the box or enclosure before attaching the cable.
- ❑ Position the cable and secure the fitting to the cable's outer sheath.
- ❑ Take care not to cut or scar the insulation on individual conductors when stripping the outer sheathing of the cable.
- ❑ Take care when tightening the securement screw of the fitting.

For cable preparation, always follow the cable manufacturer's instructions. For comprehensive guidelines on selecting and installing NM cable fittings, refer to NEMA FB 2.20, *Selection and Installation Guidelines for Flexible Conduit and Cable*.

3.2 INSERTING THE CABLE

The cable may be fed into the cable entry of the fitting or box clamp through the opening provided in the box. A sufficient working length of cable should be fed into the box or enclosure to permit cable preparation outside of the face of the box. Typically 6 in. (150 mm) of working length of cable from where it enters the box, complies with *NEC*® Section 300.14. Each conductor must be long enough to extend at least 3 in. (75 mm) outside the face of the box.

3.3 CABLE PREPARATION

The appropriate amount of the outer jacket of the cable is then removed to expose the separate conductors. Electricians use a number of techniques to strip the cable jacketing, and a wide variety of stripping tools are available. Extreme care must be taken during this process, not to damage or cut the individual conductors' insulation, or puncture, or otherwise damage the cable's jacket.

3.4 SEATING A SECUREMENT CLAMP

After preparing the cable, position the cut end of the cable jacket so that at least 1/4 in. (6 mm) extends beyond the exit end of the cable fitting or box clamp. If necessary, rotate the cable to ensure the clamp will effectively seat on a flat surface of the cable sheath when finally secured. For a round shaped cable, a flat surface can usually be found along its length, by applying gentle pressure between the thumb and index finger.

3.5 SCREW TIGHTENING TORQUE

Care should be taken during the final tightening of the cable fitting so as not to cut, puncture, or otherwise damage the cable's sheathing. The outer jacket of the cable can be damaged by over-tightening the securement screws often used with NM Cable fittings and box clamps. The screw does not have to be tightened to the point where it contacts the screw boss. Similar damage can result by over-driving a securement wedge used on some fitting designs.

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3.6 SUPPORTS

There are a variety of sizes of straps, clamps, and staples made to support NM-B Cable, UF-B or similar cable systems. See Figure 1 for examples of the common products used for securing NM-B or UF-B cable.

3.6.1 Required Intervals

3.6.1.1 Type NM-B Cable

Article 334 of the *NEC*® requires securement of Nonmetallic-Sheathed Cables at intervals not to exceed 1.4 m (4-1/2 ft) and within 300 mm (12 in.) from every cabinet, box, or fitting (note exceptions in Article 334). Design specifications usually calculate requirements based on the maximum spacing intervals that are required in the *NEC*®. Special provisions require securement of NM Cable within 20 mm (8 in.) of a single gang, nonmetallic device box where attachment of the cable to the box is not required.

3.6.1.2 Type UF-B Cable

When installed as Nonmetallic-Sheathed Cable, refer to 2.6.1.1. Type UF-B can be supported by cable trays in accordance with Article 392 of the *NEC*®. When used as an overhead cable, install as messenger-supported wiring in accordance with Article 396 of the *NEC*®. The messenger must be supported at dead ends and at intermediate locations to eliminate tension on the conductors. The conductors cannot come into contact with the messenger supports or any structural members, walls or pipes.

3.6.2 Installation in Metal Framing Members

Whether in exposed or concealed locations, where NM-B or UF-B cable passes through either punched, cut, or drilled slots or holes in metal framing members, the cable must be protected by listed bushings or grommets that completely cover the metal edges. These are securely fastened in the opening prior to installation of the cable. The holes in metal framing members are considered as a point of support for the cable.

Where there is a risk of damage to the cable from nails or screws, a steel sleeve, plate, or clip must be used to protect the cable.

3.6.3 Installation in Wood Framing Members

Where NM Cable is run parallel to, or through a framing member, it is to be positioned at least 32 mm (1.25 in.) from the inside or outside surface of a stud. Where this is not possible, a metal protector plate must be installed to prevent damage from nails or screws used in securing the wall surface.

Among the most common methods used to secure NM Cable to wood framing members are staples. While the intent of the *NEC*® is that NM Cable be securely fastened in place, care should be taken to ensure the staples are not over-driven. This can be very subjective. Although a staple driven so as to hold the cable securely may not appear to damage the cable, the pressure on the cable's sheath over time (cold flow), and the heat of the conductors may result in deterioration of the protective sheath. Many jurisdictions require metal staples to have a protective layer of non-conductive material installed between the staple saddle and the cable sheath.

NEMA recommends using insulated staples (nail straps) that have nonmetallic saddles, formed for the size of the cable for which they are designed. These can be hammer-driven or installed using a staple gun designed to drive in NM-B staples. The legs of the saddles also provide a degree of protection against over-driving of the nails. This style helps best reduce the chance of damage to the cable.

Flat NM-B and UF-B cable must always be laid flat under a staple. The NEC prohibits stapling or otherwise securing flat cable on edge! (See Figure 2) Oversized staples should not be used. Cable support devices are available that permit stacking of flat constructions so that they comply with the minimum 32 mm (1.25 in.)

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position requirement from the inside or outside surface of a stud (see Figure 1). NEMA recommends that if this installation practice is done, only staples of sufficient length should be used.

3.7 SECURING NM-B OR UF-B AT NONMETALLIC BOXES WITHOUT CABLE CLAMPS

The *NEC*® states that the cable must be supported within 200 mm (8 in.) of a nonmetallic outlet box without cable clamps, and the cable jacket must be continuous between outlet boxes and other enclosures. Where wiring devices with integral enclosures are employed with a loop of extra cable to permit future replacement of the device, the cable loop is considered to be an integral portion of the device.

3.8 UNDERGROUND INSTALLATIONS FOR UF-B

Article 300.5 of the *NEC*© contains the requirements for underground installations, including the minimum burial depth requirements in Table 300.5. UF-B can be installed by direct burial in the earth, or in raceways or enclosures where subject to physical damage; or where installed underneath buildings, driveways, sidewalks, etc.

3.9 SPECIAL INSTALLATION CONSIDERATIONS

3.9.1 Exposed Work

Type NM-B or UF-B cable is permitted for exposed work in dwellings. In structures other than dwellings, the cable must be concealed within walls, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating, as identified in listings of fire resistance rated assemblies.

In exposed work, the cable must follow the surface of the building finish or running boards, and be protected from physical damage where necessary by methods approved by the local authority having jurisdiction.

Where passing through a floor, the cable must be enclosed in conduit, tubing, surface raceway, or other approved pipe that extends at least 150 mm (6 in.) above the floor.

3.9.2 Unfinished Basements

Where NM-B or UF-B cable is run at angles with joists in unfinished basements, cables that are constructed of two 6 AWG or three 8 AWG conductors or larger can be secured directly to the lower edges of the joists. Smaller cables must be run either through bored holes in joists or on running boards.

3.9.3 Accessible Attics

The installation of NM-B or UF-B cable in accessible attics or roof spaces may require running boards or guard strips per *NEC*® Section 398.23.

3.9.4 Corrosive Locations

UF-B cable is permitted for use in corrosive environments, since the NEC permits UF-B as a substitution for Type NM-C cable. It may be installed both exposed and concealed in corrosive locations.

3.9.5 Solar Photovoltaic Systems

UF-B cable is permitted for use in solar photovoltaic systems in accordance with *NEC*® Section 690.31.

3.10 BENDING RADIUS

Bends must be made in a way that will not damage the cable. The radius of the curve of the inner edge of any bend during or after installation cannot be less than five times the diameter of the cable.

3.11 UNSUPPORTED CABLE

Cable can be unsupported where the cable is fished between access points, and where the cable is concealed in a finished building or finished panel for prefabricated buildings. Cable can also run unsupported

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where supporting is impractical, and the cable is no more than 1.4 m (4-1/2 ft) from the last point of support for connections within an accessible ceiling to luminaire(s) [lighting fixture(s)] or equipment.

3.12 AMPACITY

The ampacity of NM-B or UF-B is determined in accordance with *NEC*® Section 310.15, based on the 60°C conductor temperature rating. The use of the 90°C rating is permitted for ampacity derating purposes, provided the final de-rated ampacity does not exceed that for a 60°C rated conductor.

3.13 DAMAGE

3.13.1 Physical Damage

Wherever damage to the cable jacket or individual wires is identified, appropriate steps to remedy the situation should be taken. Damage to the sheath can be identified visually. Examples include cuts and overstretching. Examples of damage to individual wires include cuts, scrapes, and exposed conductor. NEMA recommends replacement of cable with damage to any component.

3.13.2 Flood Damage

When any wire or cable product is exposed to water, the conductor is subject to corrosion, which can damage the component itself and/or cause termination failures. Wire and cable that is listed only for dry locations, such as NM-B, may become a shock hazard, when energized, after being exposed to water.

Any wire or cable that is listed for dry locations only, such as type NM-B cable, should be replaced if it has been exposed to floodwater. For additional details, see *NEMA Guidelines for Handling Water Damaged Electrical Equipment*, which can be downloaded from the NEMA website.

3.14 VERIFICATION OF INSTALLATION

Once the cable system is fully installed, a visual check should be made to determine if adjustments are needed. This is necessary to determine if there is any loosening of system components, which sometimes may occur during construction that involves other trades. The following from NFPA 73 *Residential Electrical Maintenance Code for One- and Two-Family Dwellings,* should be followed:

1) Conductors, cables, and cable assemblies shall be properly terminated and supported at panelboards, boxes, and devices.

2) The conductor size shall be not less than the ampere rating of the circuit unless otherwise permitted for specific types of utilization equipment.

3) Splices and taps shall be made in an approved manner.

4) Cables and cable assemblies shall be properly secured and supported.

5) Conductors, cables, and cable assemblies shall not show evidence of overheating or deterioration.

6) Conductors, cables, and cable assemblies shall not show evidence of fraying, damage, or physical abuse.

During verification, a receptacle tester should be used to indicate the presence of open hot (ungrounded conductor), neutral (grounded conductor) or equipment ground (grounding conductor), or reverse polarity, to detect if any short circuits are present.

In addition, an insulation test may be conducted prior to devices being installed, to detect any possible unseen damage that a visual inspection might not reveal.

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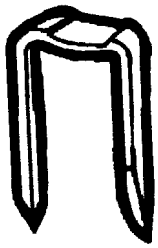
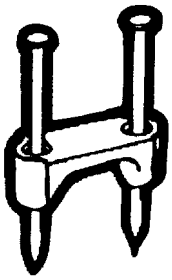


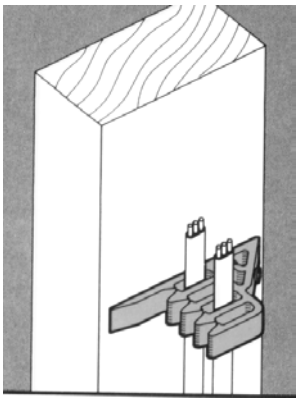
Steel Cable Staple



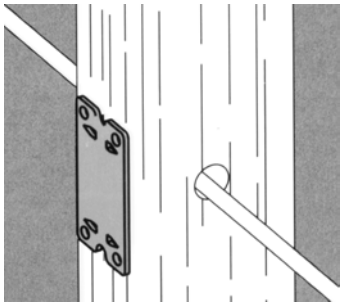
Steel Cable Staple with Non-Conductive Barrier



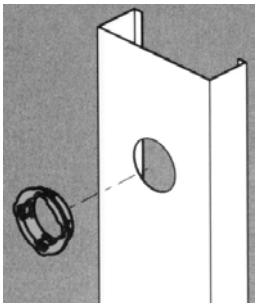
Nail Strap



Cable Stacking Support



Protector Plate



Metal Stud Bushing

Figure 1
COMMON CABLE SUPPORT AND PROTECTION PRODUCTS

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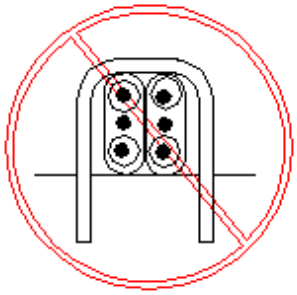
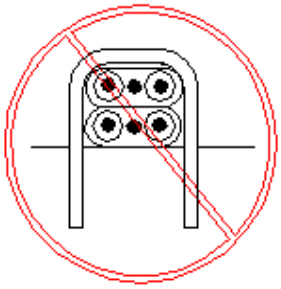
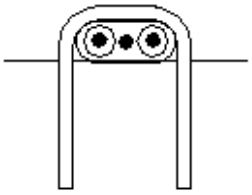


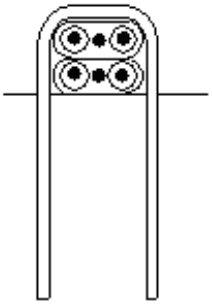
INCORRECT
Stapled with Cables on End



INCORRECT
Staple Not for Use on Two Cables



CORRECT



CORRECT
Staple for Use on Two Cables

Figure 2
POSITIONING CABLES UNDER STAPLES

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