

NECA 121



Standard for Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-Circuit Cable (Type UF)

**ANSI Canvass Draft
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1 (This foreword is not a part of the standard)
2

3 **Foreword**

4

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6 specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline
7 of quality and workmanship for installing electrical products and systems. *NEIS*[™] are intended to be
8 referenced in contract documents for electrical construction projects. The following language is
9 recommended:

10
11 Nonmetallic-sheathed cable (Type NM-B) and underground feeder and branch-circuit cable
12 (Type UF) shall be installed and maintained in accordance with NECA 121, *Standard for*
13 *Installing Nonmetallic-Sheathed Cable (Type NM-B) and Underground Feeder and Branch-*
14 *Circuit Cable (Type UF)* (ANSI).
15

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18 or non-member of NECA from specifying or using alternate construction methods permitted by
19 applicable regulations.
20

21 This publication is intended to comply with the National Electrical Code (NEC). Because they are quality
22 standards, *NEIS* may in some instances go beyond the minimum safety requirements of the NEC. It is the
23 responsibility of users of this publication to comply with state and local electrical codes and Federal and
24 state OSHA safety regulations as well as follow manufacturer installation instructions when installing
25 electrical products and systems.
26

27 Suggestions for revisions and improvements to this standard are welcome. They should be addressed to:
28

29
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1. Scope

1.1 Products and Applications Included

This standard describes installation procedures for nonmetallic-sheathed cable (Type NM-B) and underground feeder and branch-circuit cable (Type UF). This publication covers the following:

1. Nonmetallic-sheathed cable with insulation rated 90°C (194°F), listed as Type NM-B.
2. Underground feeder and branch-circuit cable, Type UF.

1.2 Products and Applications Excluded

This publication does not cover the following:

1. Nonmetallic-sheathed cable with insulation rated 60°C (140°F), listed as NM.
2. Corrosion-resistant nonmetallic-sheathed cable (Type NMC).

1.3 Regulatory and Other Requirements

All information in this publication is intended to conform to the NEC (ANSI/NFPA 70), and, in general, the typical recommendations of nonmetallic-sheathed cable and underground feeder and branch-circuit cable manufacturers. Installers shall follow the *NEC*, applicable state and local codes, manufacturer instructions, and contract documents when installing nonmetallic-sheathed cable and underground feeder and branch-circuit cable systems.

Only qualified persons familiar with the construction and operation of nonmetallic-sheathed cable and underground feeder and branch-circuit cable should perform the work described in this publication. Administrative functions such as receiving, handling, and storing required in Section 4, and other tasks may be performed under the supervision of a qualified person. All work shall be performed in accordance with NFPA 70E, *Standard for Electrical Safety in the Workplace*.

General requirements for installing electrical products and systems are described in NECA 1, *Standard Practices for Good Workmanship in Electrical Construction* (ANSI). Other NEIS provide additional guidance for installing particular types of electrical products and systems. A complete list of NEIS is provided in Annex C.

1.4 Mandatory Requirements, Permissive Requirements, Quality and Performance Recommendations, Explanatory Material, and Informative Annexes

Mandatory requirements in manufacturer instructions, or of Codes or other mandatory Standards that may or not be adopted into law, are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms “must” or “must not,” “shall” or “shall not,” or “may not,” or “are not permitted,” or “are required,” or by the use of positive phrasing of mandatory requirements. Examples of mandatory requirements may equally take the form of, “equipment must be protected . . .,” “equipment shall be protected . . .,” or “protect equipment . . .,” with the latter interpreted (understood) as “(it is necessary to, or, it is required to) protect equipment . . .”

1
2 Permissive requirements of manufacturer instructions, or of Codes or other mandatory Standards that may
3 or not be adopted into law, are those that identify actions that that are allowed but not required, or are
4 normally used to describe options or alternative means and methods, and are characterized in this
5 Standard by the use of the terms “may,” or “are permitted,” or “are not required.”
6

7 Quality and performance recommendations identify actions that are recommended or not recommended to
8 improve the overall quality or performance of the installation and are characterized by the use of the term
9 “should” or “should not.”
10

11 Explanatory material, such as references to other Codes, Standards, or documents, references to related
12 sections of this Standard, information related to another Code, Standard, or document, and supplemental
13 application and design information and data, is included throughout this Standard to expand the
14 understanding of mandatory requirements, permissive requirements, and quality and performance
15 recommendations. Such explanatory material is included for information only, and is identified by the
16 use of the term “NOTE,” or by the use of italicized text.
17

18 Non-mandatory information and other reference standards or documents relative to the application and
19 use of materials, equipment, and systems covered by this Standard are provided in informative annexes.
20 Informative annexes are not part of the enforceable requirements of this Standard, but are included for
21 information purposes only.
22
23

24 **2. Definitions**

25
26 **Accessible (as applied to wiring methods).** Capable of being removed or exposed without
27 damaging the building structure or finish or not permanently closed in by the structure or finish of the
28 building.
29

30 **Authority Having Jurisdiction (AHJ).** An organization, office, or individual responsible for
31 enforcing the requirements of a code or standard, or for approving equipment, materials, an installation,
32 or a procedure. *NOTE: The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA*
33 *documents in a broad manner, since jurisdictions and approval agencies vary, as do their*
34 *responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state,*
35 *local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire*
36 *prevention bureau, labor department, or health department; building official; electrical inspector; or*
37 *others having statutory authority. For insurance purposes, an insurance inspection department, rating*
38 *bureau, or other insurance company representative may be the authority having jurisdiction. In many*
39 *circumstances, the property owner or his or her designated agent assumes the role of the authority having*
40 *jurisdiction; at government installations, the commanding officer or departmental official may be the*
41 *authority having jurisdiction.*
42

43 **Concealed.** Rendered inaccessible by the structure or finish of the building. *NOTE: Wires in concealed*
44 *raceways are considered concealed, even though they may become accessible by withdrawing them.*
45

46 **Exposed (as applied to wiring methods).** On or attached to the surface or behind panels designed to
47 allow access.

1
2 **Nonmetallic-Sheathed Cable.** A factory assembly of two or more insulated conductors enclosed
3 within an overall nonmetallic jacket.
4

5 **Type NM.** Insulated conductors enclosed within an overall nonmetallic jacket.
6

7 **Type NMC.** Insulated conductors enclosed within an overall, corrosion resistant, nonmetallic jacket.
8

9 **Type NMS.** Insulated power or control conductors with signaling, data, and communications
10 conductors within an overall nonmetallic jacket.
11

12 *NOTE: The NEC recognizes three cable types—Types NM-B, NMC, and NMS. Currently, Types NMC*
13 *and NMS are not commercially available, but Type UF-B can be substituted for NMC. Type NMS is a*
14 *construction consisting of NM-B and data/communication cables.*
15

16 **Underground Feeder and Branch-Circuit Cable, Type UF.** A factory assembly of one or more
17 insulated conductors with an integral or an overall covering of nonmetallic material suitable for direct
18 burial in the earth. *NOTE: The National Electrical Code recognizes one type of underground feeder and*
19 *branch circuit cable, Type UF. Multiconductor cables are identified as UF-B, indicating that the circuit*
20 *conductors are rated 90°C dry and at least 60°C wet, and that the jacket is rated at least 75°C. The*
21 *ampacity of these cables is that of 60°C rated conductors. Type UF cables are a flat construction.*
22
23

24 **3. Safety**

25
26 *NOTE: The process of de-energizing conductors and equipment is considered “live” work and can result*
27 *in an arc flash due to equipment failure. When de-energizing conductors and equipment, follow safety*
28 *procedures for working on or near live circuits. Failure to observe these precautions may result in*
29 *severe personal injury or death.*
30

31 Before performing cleaning, inspections, testing, maintenance, or repairs, electrically isolate conductors
32 and equipment in accordance with established written procedures. All work and actions must conform to
33 the requirements of NFPA 70E, Electrical Safety in the Workplace.
34
35

36 **3.1 General**

37
38 For electrical equipment to work properly, it must be handled carefully and installed, operated, and
39 maintained correctly. Neglecting fundamental installation and maintenance requirements can lead to
40 severe personal injury or death, and damage to conductors, electrical equipment, and other property.
41

42 Consider all circuits and ungrounded and grounded metal parts of equipment and devices to be energized
43 at the highest voltage to which they are exposed unless they are de-energized, tested, locked out of
44 operation, and tagged in accordance with OSHA requirements.
45

46 Do not work on energized conductors or equipment. Electrically isolate conductors and equipment in
47 accordance with established procedures and manufacturer instructions. Disconnect power to motors and

1 motor controllers before performing service or maintenance. Discharge all capacitors before servicing
2 motors.

3
4 Use care in opening and closing doors, access panels, and covers of energized equipment. Conductors
5 and terminations may be exposed and within the reach of openings.

6
7 Do not enter equipment enclosures when components are energized. Do not remove access covers, doors,
8 or panels when equipment is energized. Do not expose conductors, connections, or terminations when
9 components are energized. Using established safety procedures, guard energized conductors and
10 equipment in close proximity to work.

11 12 13 **3.2 Safe Work Practices**

14
15 Perform preliminary inspections and tests prior to beginning work to determine existing conditions.
16 Check existing conditions against available record documents.

17
18 Visually verify all connections to equipment. Confirm that conductors are connected properly. Keep in
19 mind that transposed conductors may be connected to different terminals than expected.

20
21 Resolve discrepancies between installed conditions and electrical drawings. Have drawings corrected, if
22 required. Provide warning labels on equipment and cables where necessary to indicate unexpected and
23 potentially hazardous conditions.

24
25 Maintain as much distance as practical from equipment and devices that may arc during operation or
26 handling, but not less than the arc flash protection boundary specified in NFPA 70E.

27
28 Use insulated hand tools when working on or around energized equipment. Use only properly rated tools
29 for the energy present. Maintain tool inventories to ensure that all tools are accounted for prior to
30 energizing equipment.

31
32 Ensure that egress from the work area is unobstructed, and that fire extinguishers approved for use in
33 electrical fires are readily available.

34
35 Do not modify, bypass, disable, or defeat interlocks, protective devices, or safety guards. Safety features
36 are designed to prevent severe personal injury or death and damage to equipment.

37 38 39 **3.3 Personal Protective Equipment (PPE)**

40
41 Wear appropriate PPE in accordance with the incident energy levels of the equipment, and use established
42 safety procedures when working on or near energized electrical equipment or equipment that has not been
43 de-energized, tested, grounded, locked out of operation, and tagged in accordance with NFPA 70E.

44
45 Wear 100 percent natural fiber clothing or flame resistant apparel. Do not wear conductive articles such
46 as watches, rings, or necklaces.

3.4 De-Energizing Electrical Equipment

Follow all manufacturer instructions and recommendations for electrically isolating equipment and components. Ensure equipment is in an electrically safe work condition. Follow lock-out/tag-out procedures. Disconnect all sources of power before opening any enclosures or compartments. Verify that source circuit breakers and switches are open.

Identify all sources of power to conductors and equipment. Interrupt the load current before opening the disconnecting means for each power source. Where possible, visually verify that blades of disconnecting means are fully open and that drawout-type circuit breakers are fully withdrawn.

Test conductors and equipment at both the source(s) and equipment terminals for the presence of voltage. Use electrical testing equipment rated for the operating voltage of the system. Test the voltage sensing equipment on a known, energized source immediately before and after testing the equipment to be tested to ensure that the voltage sensing equipment is operating properly.

Apply lockout/tagout devices in accordance with a formal, written policy and in accordance with NFPA 70E-2012, *Electrical Safety in the Workplace*. Padlock and tag all source switching devices in the open position. Remove locks and tags only after work is complete and tested, and all personnel are clear of the area. Protect against accidental energization of automatic or remotely controlled equipment by identifying, opening, locking, and tagging starting devices. Open and lock or tag all load isolation devices to ensure that there are no loads connected to the equipment.

Carefully inspect the work area and remove any tools and objects left inside before energizing conductors and equipment. Install all devices, panels, doors, and covers before energizing.

4. Receiving, Handling, and Storage

4.1 Receiving

Upon delivery of cables and accessories, visually inspect cables, reels, and packaging for physical damage, including any indication of dampness or other water damage. If damage is evident, notify the shipper and the manufacturer in writing immediately. Do not proceed with installation until appropriate actions to clean or replace the equipment have been taken. Repair or replace damaged components in accordance with manufacturer instructions.

Compare cables and accessories received with the bill of materials to verify that the shipment is complete. If the shipment is not complete, notify the manufacturer in writing immediately and note shortages on the Bill of Materials.

Verify that the cables and accessories received conform with the approved submittals and manufacturer's quotation. If they do not, notify the manufacturer in writing immediately.

If cable reels are to be stored prior to installation, restore original packing materials as much as possible,

1 or cover with heavy plastic or canvas to protect equipment from exposure to moisture, dust, dirt, and
2 contaminants. When conditions permit, leave the packing materials intact until equipment is ready for
3 installation.
4

5 6 **4.2 Handling**

7
8 Handle cables and accessories in accordance with manufacturer instructions.
9

10 Handle cables carefully to avoid abrading, puncturing, or tearing cable insulation and sheathing. Avoid
11 subjecting cables to impact, jolting, jarring, and rough handling.
12

13 Verify that the weights and dimensions of cable reels are within the rated capacity of the handling
14 equipment. Lift smoothly and gently.
15

16 Use care to balance and distribute weight when handling cable reels with platform dollies, platform lifts,
17 forklift trucks, skids, and rollers to prevent overturning. Do not damage cable sheath or protective
18 wrappings with forks of forklift.
19

20 Lift cable reels using a cradle or shaft through the arbor hole in the reel. Do not lift reels by pulling or
21 lifting by the cable that is wound on the reel.
22

23 24 **4.3 Storage**

25
26 Store cables and accessories in accordance with manufacturer's instructions.
27

28 Store cable reels in an area to discourage vandalism, and out of the way of construction traffic.
29 Protect cables and accessories from excessive dust, dirt, moisture, and contamination.
30

31 Store cables in a clean, dry space in original packaging. Provide supplemental heating if air
32 temperature at cable storage location will be below 4°C (40°F), or relocate cable to a heated
33 location to maintain cable temperature of 10°C (50°F) or higher.
34

35 Store cables on a hard surface to prevent the reel from sinking into the surface, causing the cable
36 to support its weight and the weight of the reel. Block cable reels to prevent accidental rolling.
37 Do not store cable reels on their sides unless recommended by the cable manufacturer.
38
39

40 **5. Construction of NM-B and UF Cables**

41 42 **5.1 Type NM-B**

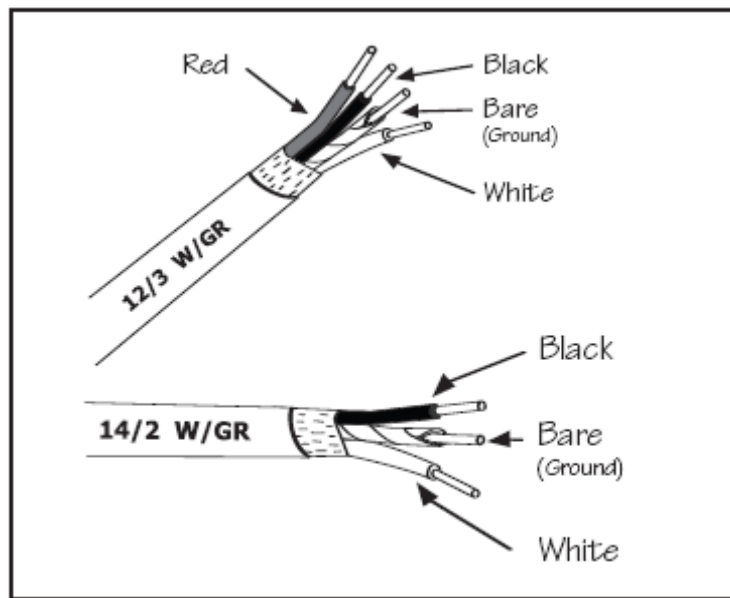
43
44 Type NM-B cable has an overall covering that is flame-retardant and moisture-resistant. The cable is
45 rated 600V and is listed in sizes 14 AWG (American wire gauge) through 2 AWG with copper

1 conductors, and in sizes 12 AWG through 2 AWG with copper-clad or aluminum conductors.

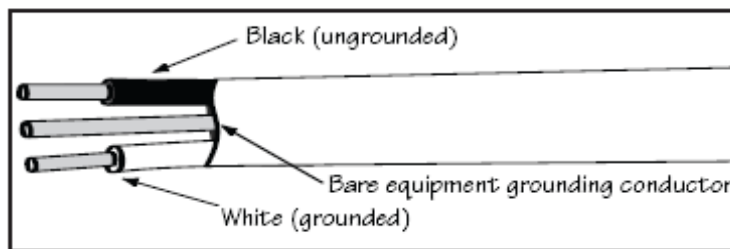
2
3 Type NM-B cables are required to be durably marked on the surface to indicate the following
4 information:

- 5 • Maximum rated voltage
- 6 • Type of conductors
- 7 • Manufacturer's name or trademark
- 8 • AWG or circular mil size

9
10 Figure 5.1.1 shows typical NM-B cables marked with the conductor size and number of conductors. The
11 insulated conductors are rated 90°C (194°F). Type NM-B cable is required to have an insulated (green)
12 or bare conductor, which must be used for equipment-grounding purposes only. The equipment
13 grounding conductor is sized in accordance with NEC Table 250.122, see Annex A. Bare grounding
14 conductors are wrapped in paper to prevent contact with the insulated conductors. Type NM-B cable is
15 available in either flat or round construction. In flat Type NM-B cable, the grounding conductor is
16 located directly between the circuit conductors. (See Figure 5.1.2.)
17



18
19
20
21 *Figure 5.1.1: Type NM-B cable showing marking on cables*



22

Figure 5.1.2: Flat type NM-B cable

The letters "W/GR" indicate that a separate equipment grounding conductor is present.

5.2 Type UF Cable

Type UF cable has an overall covering that is flame-retardant, moisture- and corrosion-resistant, and suitable for use as direct burial in the earth. The cable is rated 600V and is listed in sizes 14 AWG through 4/0 AWG with copper conductors, and in sizes 12 AWG through 4/0 AWG with copper-clad aluminum or aluminum conductors. The cable is permitted to have an insulated (green) or bare conductor that may be used for equipment grounding purposes only. Where Type UF is installed as a substitute wiring method for nonmetallic-sheathed cable, the conductor insulation shall be rated 90°C (194°F). (See Figure 5.2.)

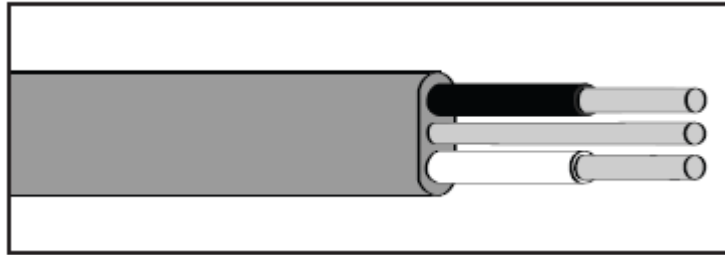


Figure 5.2: Type UF cable

Type UF cables are required to be durably marked on the surface to indicate the following information:

- Maximum rated voltage
- Manufacturer's name or trademark
- AWG or circular mil size

5.3 Cable Covering

Although not a listing requirement or an NEC requirement, the use of the following colors for the NM-B cable overall covering is generally accepted throughout industry for identifying cable conductor sizes:

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

6. Applications and Uses

6.1 General

1
2 Consult the latest version of the NEC and manufacturer installation instructions for permitted uses of
3 Type NM-B and Type UF cables before starting work. Type NM-B cable and Type UF are required to be
4 listed in accordance with the NEC.
5

6 7 **6.2 Type NM-B Cable**

8 9 **6.2.1 Type NM-B Cable Permitted Uses**

10
11 Type NM-B cable is permitted to be used in any one-or two-family dwelling and their attached or
12 detached garages, and their storage buildings.
13

14 Type NM-B cable is permitted to be used in multifamily dwellings and other structures only in Type III (a
15 combination of combustible and non-combustible), Type IV (heavy timber), and Type V (wood frame)
16 fire-rated construction as defined in NFPA 220, *Standard on Types of Building Construction*, or the
17 applicable building code, or both. *NOTE: Types III, IV, and V permit some or all of the structure to be*
18 *combustible (wood).* In structures that are Types III, IV, or V fire-rated construction, other than
19 dwellings, cables must be concealed in walls, floors, or ceilings that provide a thermal barrier that has at
20 least a 15-minute finish rating as identified in listings of fire-rated assemblies.
21

22 Type NM-B cables are permitted to be installed in cable trays in structures permitted to be Types III, IV,
23 or V construction where the cables are identified for the use. *NOTE: See NEC Section 310.15(A)(3) for*
24 *temperature limitation of conductors.*
25

26 Type NM-B cables are permitted to be installed in Types I and II construction where installed within
27 raceways permitted to be installed in Types I and II construction.
28

29 Type NM-B cable can be used for both exposed and concealed work in normally dry locations and can be
30 installed or fished in air voids in masonry block or tile walls.
31

32 Use of Type NM-B in multifamily and other structures is restricted to buildings of five stories or less.
33
34

35 **6.2.2 Type NM-B Cable Uses Not Permitted**

36
37 Type NM-B cable is not permitted to be installed in any dwelling or structure not specifically permitted in
38 Section 6.2.1 or in the NEC.
39

40 Type NM-B cable is not permitted to be installed exposed in dropped or suspended ceilings in other than
41 one- and two-family and multifamily dwellings.
42

43 Type NM-B cable is not permitted to be installed as service-entrance cable.
44

45 Type NM-B cable is not permitted to be installed in theaters or similar locations except where permitted
46 in NEC Article 518, in motion picture studios, in storage battery rooms, in hoistways or on elevators or
47 escalators, in commercial garages having hazardous (classified) locations as defined in NEC Article 500,

1 embedded in poured cement, concrete, or aggregate, or in hazardous (classified) locations except where
2 specifically permitted in the NEC.

3
4 Type NM-B cable is not permitted to be installed in wet or damp locations, where exposed to corrosive
5 fumes or vapors, where embedded in masonry, cement, concrete, adobe, fill, aggregate, or plaster, or in a
6 shallow chase in masonry, concrete, or adobe and covered with plaster, adobe, or similar finish.

7 8 9 **6.3 Type UF Cable**

10 11 **6.3.1 Type UF Cable Permitted Uses**

12
13 Type UF cable is permitted to be used underground, including direct burial in the earth. *NOTE: See NEC*
14 *Section 300.5 for underground installation requirements.* Where installed as a single conductor cable, all
15 conductors of the feeder or branch-circuit, including the grounded conductor and the equipment-
16 grounding conductor, must be contained within the same raceway, auxiliary gutter, cable tray, or trench.

17
18 Type UF cable is permitted to be installed in wet, dry, or corrosive locations in accordance with a
19 recognized wiring method. Where installed as nonmetallic-sheathed cable, Type UF cable must be
20 installed in compliance with Parts II and III of NEC Article 334 subject to the conductor temperature
21 limitations in NEC Section 310.14(A)(3), and must be of the multiconductor type. See Section 10.

22
23 Type UF cable is permitted to be used for solar photovoltaic systems in accordance with NEC Section
24 690.31.

25
26 Type UF cable is permitted to be used as single-conductor cables as the non-heating leads for heating
27 cables as provided in NEC Section 424.43.

28
29 Type UF cables, multiconductor type, are permitted to be supported by cables trays. *NOTE: See NEC*
30 *Section 310.15(A)(3) for temperature limitation of conductors.*

31 32 33 **6.3.2 Type UF Cable Uses Not Permitted**

34
35 Type UF cable is not permitted to be installed where exposed to the direct rays of the sun unless identified
36 as sunlight resistant.

37
38 Type UF cable is not permitted to be used as service-entrance cable.

39
40 Type UF cable is not permitted to be installed in theaters or similar locations, in motion picture studios, in
41 storage battery rooms, in hoistways or on elevators or escalators, in commercial garages, embedded in
42 poured cement, concrete, or aggregate except where embedded in plaster as non-heating leads where
43 permitted in NEC Section 424.43, or in hazardous (classified) locations except where specifically
44 permitted by the NEC.

45
46 Type UF cable is not permitted to be installed as overhead cable except where installed as messenger-
47 supported wiring in accordance with Part II of NEC Article 396.

7. Ampacity

7.1 Type NM-B Cable

The ampacity of Types NM-B cable shall be determined in accordance with NEC Section 310.15. Type NM-B Cable insulated power conductors are required to have 90°C (194°F) rated insulation. The allowable ampacity of Type NM-B power conductors, however, is limited that of a 60°C (140°F) rated conductor using NEC Table 310.15(B)(16). For ampacity adjustment and correction calculations, the 90°C (194°F) rating is permitted to be used, provided the final derated conductor ampacity does not exceed that of a 60°C (140°F) rated conductor.

It is important to maintain spacing between cables to prevent any buildup of heat. Where multiconductor cables are stacked or bundled together for lengths longer than 600 mm (24 inches), the allowable ampacity of each current-carrying conductor must be reduced in accordance with NEC Table 310.15(B)(3)(a). *NOTE: Bundling is not defined in the NEC but is generally accepted to mean cables or conductors that are physically tied, wrapped, taped, or otherwise periodically bound together. Stacking generally means installing cables or conductors in close proximity without spacing between cables and without physically tying, wrapping, taping, or otherwise binding them together. See Annex B. See Figure 7.1.1.*

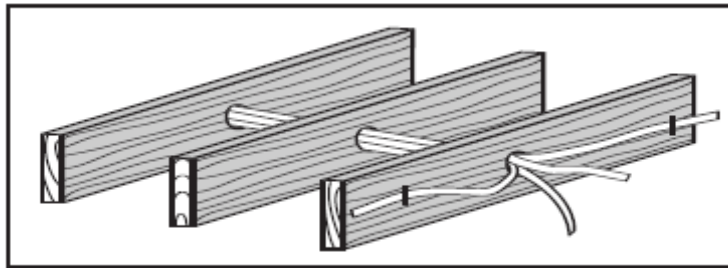


Figure 7.1.1: Stacking or bundling cables

Where more than two Type NM-B cables containing two or more current-carrying conductors are installed, without maintaining spacing between the cables, through the same opening in wood framing that is to be sealed with thermal insulation, caulk, or sealing foam, the allowable ampacity of each conductor shall be adjusted in accordance with NEC Table 310.15(B)(3)(a) and the provisions of NEC Section 310.15(A)(2), Exception, shall not apply. See Figure 7.1.2.

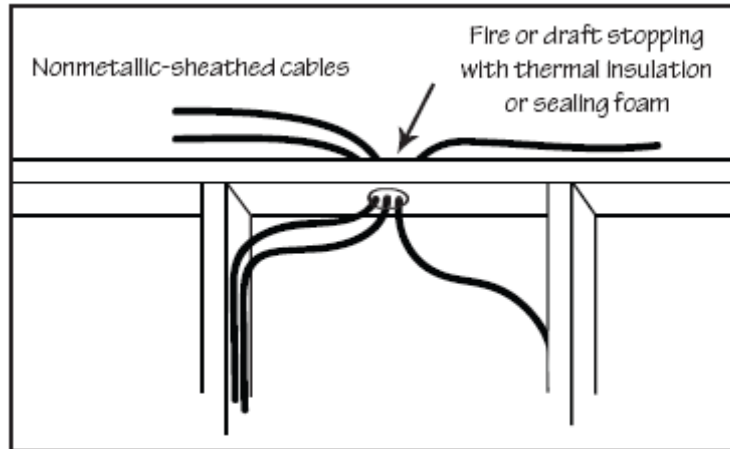


Figure 7.1.2: Two or more cables through fire or draft stopping

Where more than two Type NM-B cables containing two or more current-carrying conductors are installed in contact with thermal insulation without maintaining spacing between cables, the allowable ampacity of each conductor shall be adjusted in accordance with Table 310.15(B)(3)(a).

See Annex B for guidance in applying adjustment and correction factors for derating conductor ampacity due to ambient temperature, and for more than three current carrying conductors in a cable (or bundling or stacking of cables).

7.2 Type UF Cable

The ampacity of the insulated power conductors of Type UF Cable shall be that of 60°C (140°F) conductors in accordance with NEC Section 310.15. Where installed as nonmetallic-sheathed cable, the installation and conductor requirements shall comply with Parts II and III of NEC Article 334 and shall be of the multiconductor type. The conductor insulation shall be rated 90°C (194°F). The ampacity derating requirements are identical to those of NM-B cable.

See Annex B for guidance applying adjustment and correction factors for derating conductor ampacity due to ambient temperature, for more than three current carrying conductors in a cable (or bundling or stacking of cables), and for rooftop installations.

8. Installation Considerations

Type NM-B and Type UF cables are permitted for exposed work in dwellings. In structures other than dwellings, cables 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.

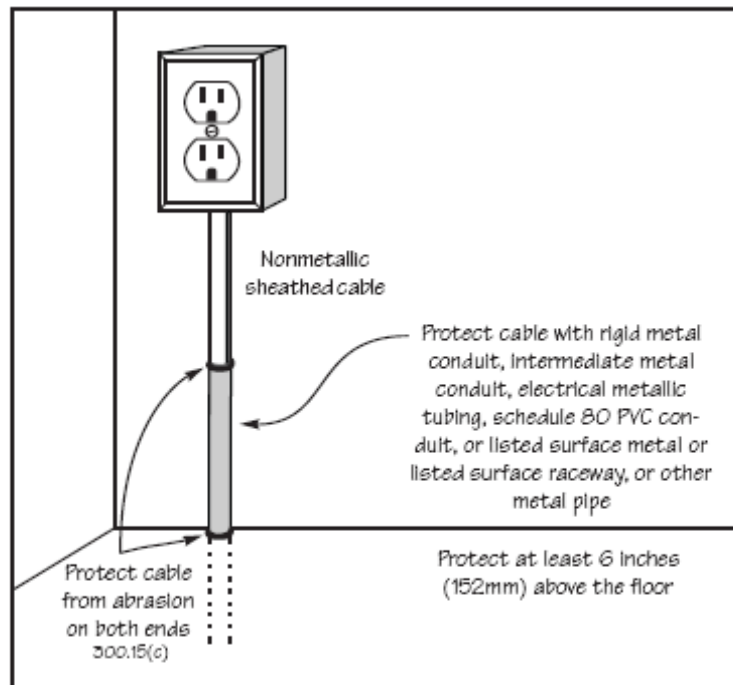
1 In exposed work, cables must follow the surface of the building finish or running boards, such as joists or
 2 studs, and must be protected from physical damage where necessary by methods approved by the local
 3 authority having jurisdiction.
 4
 5

6 **8.1 Protection from Physical Damage**
 7

8 Provide physical protection of Type NM-B and UF cables. Do not install in locations where exposed to
 9 physical damage.
 10

11 **8.1.1 Passing Through Floors**
 12

13 Type NM-B and Type UF cables must be protected from physical damage where necessary by installing
 14 sleeves made from rigid or intermediate metal conduit, electrical metallic tubing, Schedule 80 PVC rigid
 15 nonmetallic conduit, or other means approved by the Authority Having Jurisdiction (AHJ). Where
 16 passing through a floor, extend this protection at least 150 mm (6 inches) above the floor. Provide a
 17 fitting on both ends of the conduit or tubing to protect the cable from abrasion (see Figure 8.1.1).
 18



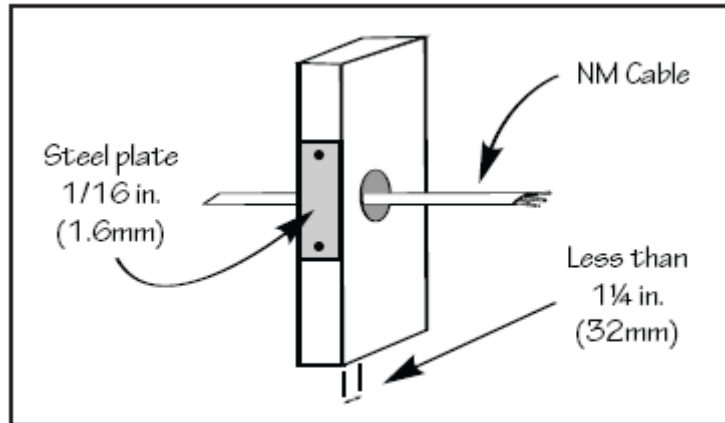
19 *Figure 5: Cable passing through floors*
 20

21 *Figure 8.1.1: Cable passing through floors*
 22

23 **8.1.2 Bored Holes**
 24

25 Where cable is installed through bored holes in joists, rafters, or wood members, holes must be bored so
 26 that the edge of the hole is not less than 32 cm (1-1/4 inches) from the nearest edge of the wood member.
 27

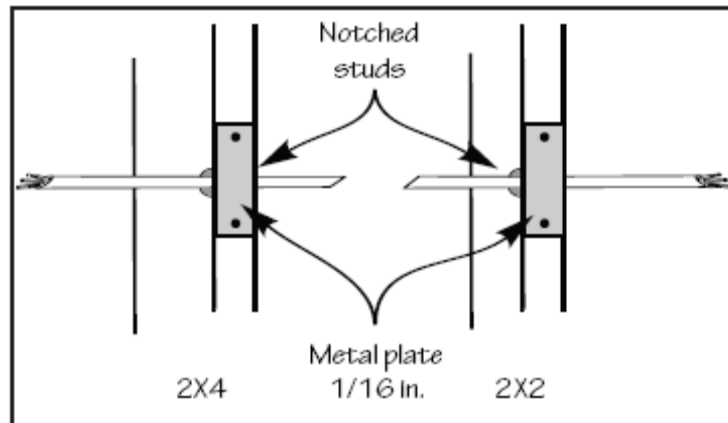
1 Where this distance cannot be maintained, protect the cable by a steel plate or bushing at least 1.6 mm
 2 (1/16 inch) thick to prevent damage to the cable from nails or screws being driven into the cable (see
 3 Figure 8.1.2). A listed and marked steel plate less than 1.6 mm (1/16 inch) thick that provides equal
 4 protection against nail or screw penetration is permitted.
 5



6
 7 *Figure 6: Cable through bored holes*
 8 *Figure 8.1.2: Cable through bored holes*
 9

10
 11 **8.1.3 Notches in Wood Studs**

12
 13 Where it is acceptable to notch wood members, in both concealed and exposed locations, cables may be
 14 laid in notches in wood members where the cable is protected by a steel plate at least 1.6 mm (1/16 inch)
 15 thick installed to cover the area of the cable (see Figure 8.1.3). A listed and marked steel plate less than
 16 1.6 mm (1/16 inch) thick that provides equal protection against nail or screw penetration is permitted.
 17 Exercise caution to limit the size and depth of notches cut into wood members so as not to weaken the
 18 strength of the structure. Obtain approval of the AHJ before notching wood members.
 19



20
 21
 22 *Figure 8.1.3: Notches in wood studs*
 23

8.1.4 Metal Framing Members

In both exposed and concealed locations where cables pass through punched, cut, or drilled holes or slots in metal framing members, the cable must be protected by listed bushings or grommets covering all metal edges of the framing member (see Figure 8.1.4). The bushings or grommets must be installed prior to the installation of the cables. Listed bushings or grommets fit securely in the opening in the metal stud and meet the stringent pullout requirements of the product standard. Figure 8.1.4 shows two types of grommets available for this purpose. Where nails or screws are likely to penetrate the cable, a steel sleeve or steel plate not less than 1.6 mm (1/16 inch) thickness must be used to protect the cable. A listed and marked steel plate less than 1.6 mm (1/16 inches) thick that provides equal protection against nail or screw penetration is permitted.

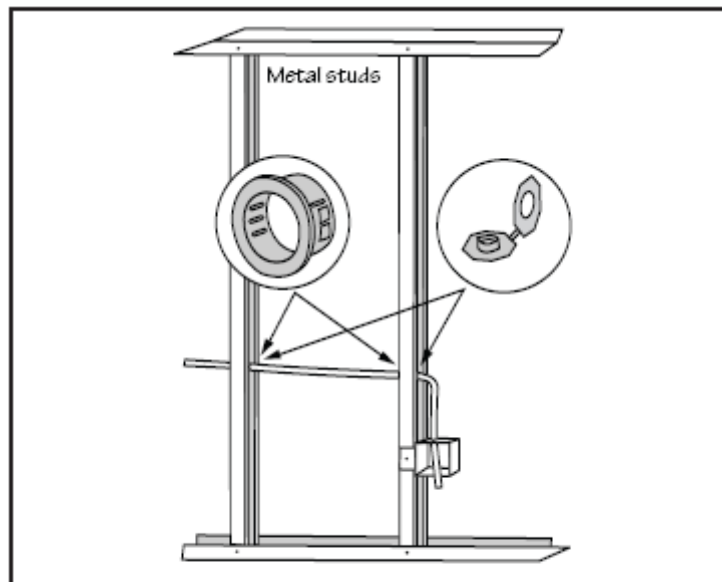


Figure 8: Bushings or grommets metal framing members

Figure 8.1.4: Bushings or grommets metal framing members

8.1.5 Accessible Attics

Cables installed in accessible attics where run across the top of floor joists or run across the face of rafters or studding within 2.1 m (7 feet) of the floor or floor joists must be protected by substantial guard strips that are at least as high as the cable. Where this space is not accessible by permanent stairs or ladders, protection is only required within 1.8 m (6 feet) of the scuttle hole or attic entrance. Where the cable is installed parallel to rafters, studs, or floor joists, guard strips are not required.

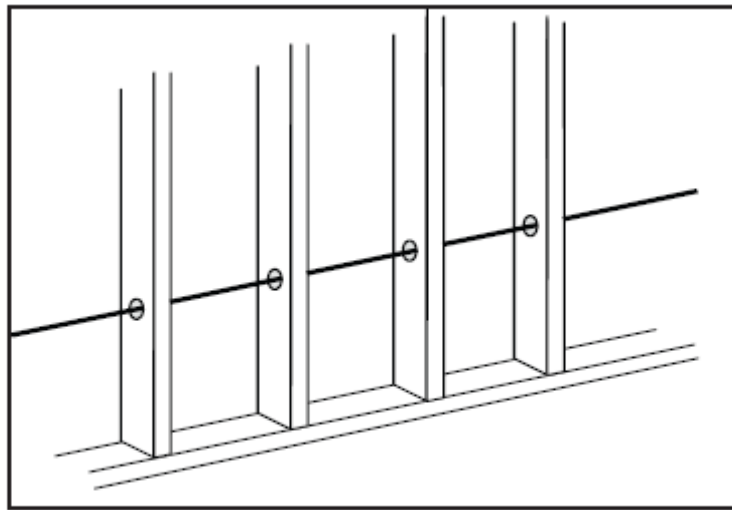
8.2 Securing and Supporting Cables

NECA 121

1 Support and secure cables by staples, cable ties, straps, hangers, or similar fittings designed and installed
2 so as not to damage the cable. *NOTE: Sections of cable protected from physical damage by raceway are*
3 *not required to be secured within the raceway.*
4

5 Ensure that staples are not over-driven, which can damage the outer sheath and/or the conductor
6 insulation. Check with the AHJ whether metal staples are required to have a protective layer of non-
7 conductive material installed between the staple saddle and the cable sheath. *NOTE: It is recommended*
8 *to use insulated staples (nail straps) that have nonmetallic saddles that are formed for the size of the*
9 *cable for which they are designed. The legs of the saddle provide protection against over-driving the*
10 *nails.* Do not use oversized staples.
11

12 In other than vertical runs, cables installed in horizontal runs through slots, holes, and notches in framing
13 members are considered to be supported and secured where such support does not exceed 1.4 m (4-1/2-
14 foot) intervals, and the cable is securely fastened in place by an approved means within 300 mm (12
15 inches) of each box, cabinet, conduit body, or other cable termination. See Figure 8.2.
16
17



18
19
20 *Figure 8.2: Cables run horizontally through holes and notches are considered to be supported*
21

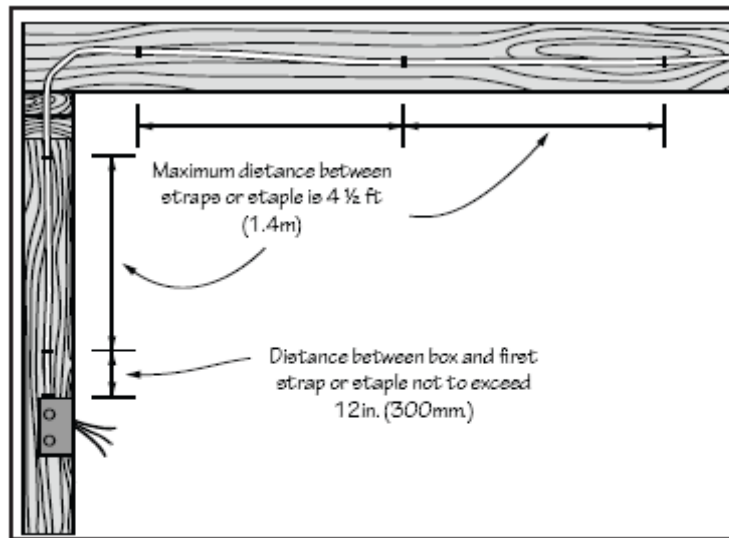
22 Nonmetallic-sheathed cable is permitted to be unsupported where the cable:

- 23 • Is fished between access points through concealed spaces in finished buildings or structures and
24 supporting is impracticable.
- 25 • Is not more than 1.4 m (4-1/2 feet) from the last point of cable support to the point of connection
26 to a lighting fixture or other piece of electrical equipment and the cable and point of connection
27 are within an accessible ceiling.
- 28 • Is connected to a wiring device identified for the use, without a separate outlet box, and
29 incorporating an integral cable clamp where the cable is secured in place at intervals not
30 exceeding 1.4 m (4-1/2 feet) and within 300 mm (12 inches) from the wiring device wall opening,
31 and there is at least a 300 mm (12 inch) loop of unbroken cable or 150 mm (6 inches) of a cable
32 end available on the interior side of the finished wall to permit replacement.

1
2 Type UF cable can be supported by cable tray in accordance with Article 392 of the NEC. When used as
3 an overhead cable, install as messenger supported wiring in accordance with Article 396 of the NEC. The
4 messenger must be supported at dead ends and at intermediate locations to eliminate tension on the
5 conductors. The conductors cannot come into contact with the messenger supports or any structural
6 members, walls, or pipes.
7
8

9 **8.2.1 Cable Supports**

10 Type NM-B and Type UF cables must be supported and secured by staples, cable ties, straps, hangers, or
11 similar fittings installed so as not to damage the cable. Support and secure cables at intervals not to
12 exceed 1.4 m (4-1/2 feet) and within 300 mm (12 inches) of every outlet box, junction box, cabinet, or
13 fitting (see Figure 8.2.1.1).
14
15



16
17
18 *Figure 8.2.1.1: NM-B cable supported at 1.4 m (4-1/2 foot) intervals and within 300 mm (12 inches) of*
19 *every outlet box*

20
21 Staple flat-constructed cables flat; do not staple flat-constructed cables on their edge (see Figure 8.2.1.2).
22

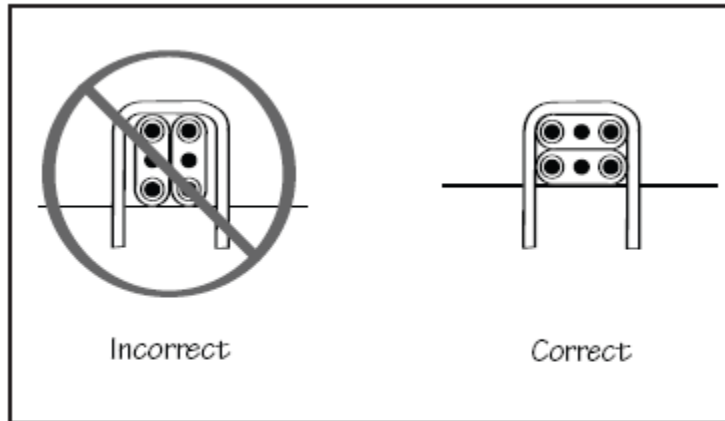


Figure 9: Flat cables not stapled on edge

Figure 8.2.1.2: Flat cables not stapled on edge

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6 **8.2.2 Spaces Behind Panels**

7
8 Cables installed behind panels designed to allow access must be supported and secured by staples, cable
9 ties, or similar fittings designed so as not to damage the cable. In other than one- and two-family and
10 multifamily dwellings, cable is not permitted to be run exposed. Installations in raceways are considered
11 to be concealed.
12
13

14 **8.2.3 Unfinished Basements and Crawl Spaces**

15
16 Where cables are run at angles with joists in unfinished basements and crawl spaces, cables not smaller
17 than two 6 AWG or three 8 AWG may be secured directly to the lower edge of the joists. Smaller cables
18 must be run through bored holes in joists or on running boards (see Figure 8.2.3.1).
19

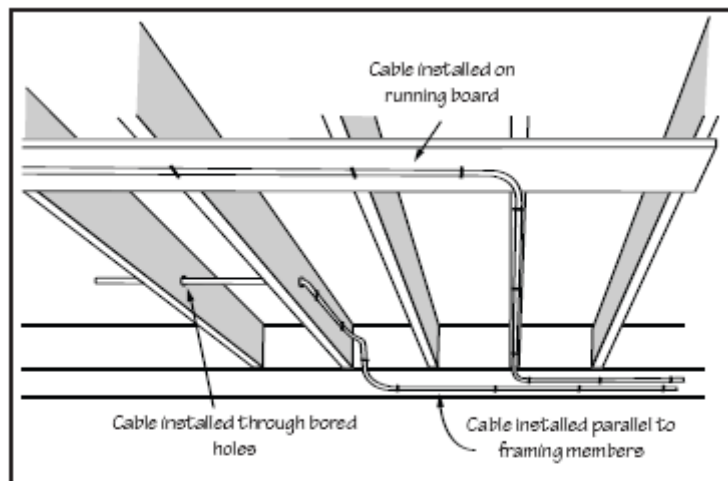


Figure 8.2.3.1: Cables in unfinished basements

Cables installed on the surface of a wall of an unfinished basement may be installed in a listed conduit or tubing. A nonmetallic bushing or adapter must be used where the cable enters the raceway to protect the cable from the edge of the raceway. The cable must be secured within 300 mm (12 inches) of the point where the cable enters the conduit or tubing. Where such raceways terminate at an outlet or device box, the cable sheath must extend through the conduit or tubing and into the outlet or device box not less than 6 mm (1/4 in.). Metal conduit, tubing, and metal outlet boxes shall be connected to an equipment grounding conductor complying with the provisions of NEC Sections 250.86 and 250.148. (See Figure 8.2.3.2).

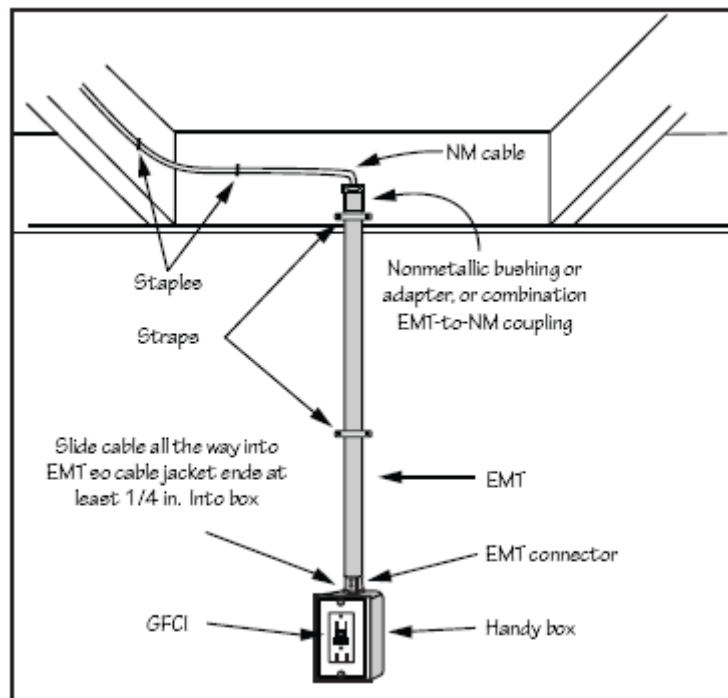


Figure 8.2.3.2: Cables on walls in unfinished basements

8.3 Boxes and Enclosures

Type NM-B and UF cables are permitted to be installed in both metallic and nonmetallic outlet boxes. Install boxes prior to installing Type NM-B and UF cables. Attach fittings to knockouts in a box or enclosure prior to installing cable. See Section 8.4 for additional information. Install and prepare Type NM-B and UF cables for connections and terminations in accordance with manufacturer instructions. Install sufficient cable lengths to enable sheathing to be removed to expose the prescribed length of conductor.

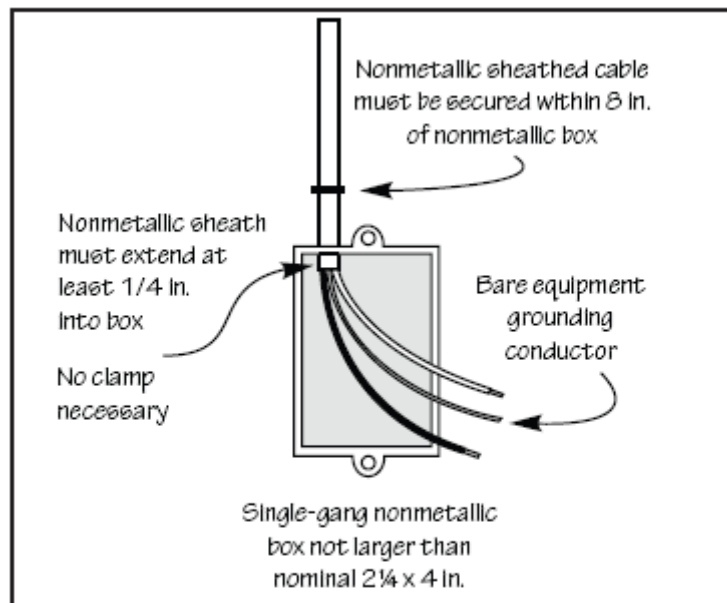
Remove nonconductive coatings in the locknut area on metal enclosures to assure that an effective electrical bond is achieved. Hand tighten locknuts, when provided with fittings, prior to installing cables.

1 After completing cable installation, tighten locknuts an additional one-quarter turn using manufacturer-
 2 approved tools and methods. When securing the locknut, avoid excessive pressure when gripping the
 3 fitting. Do not tighten the fitting to the locknut. Fittings secured to a box or enclosure by means other
 4 than a locknut should be assembled to the box and the cable according to the manufacturer's instructions.
 5

6 Nonmetallic cable fittings that have external threads can be installed to threaded entries provided in
 7 certain boxes, enclosures, and conduit bodies. Ensure that at least 3-½ threads of the connector are fully
 8 engaged with the threads of the conduit entry. Carefully tighten threaded fittings using a wrench.
 9

10 8.3.1 Nonmetallic Boxes

11 The sheath of Type NM-B cable or Type UF cable must extend a minimum of 6 mm (1/4 inch) inside the
 12 box and beyond any fitting, connector, or cable clamp. Type NM-B and Type UF cables must be secured
 13 to boxes except for cables used with single gang boxes not larger than 57 mm x 100 mm (2-1/4 inches x 4
 14 inches) mounted in walls or ceilings, except where the cable is fastened within 200 mm (8 inches) of the
 15 box, and except where the cable sheath extends through a cable knockout less than 6 mm (1/4 inch) (see
 16 Figure 8.3.1).
 17
 18
 19



20
 21
 22 *Figure 8.3.1: Securing cable to 2-1/4"x4" nonmetallic box*
 23
 24

25 8.3.2 Nails and Screws

26 Where nails or screws are used to fasten the box, they must pass through the interior within 6 mm (1/4
 27 inch) of the back of the box. Exposed threads of screws in the box must be covered by approved means to
 28 avoid abrasion of conductor insulation.
 29
 30

8.3.3 Metal Cover Plates

Where metal cover plates are used with nonmetallic boxes, a means must be provided to ground the metal coverplate to the equipment grounding conductor.

8.4 Cable Fittings and Connectors

Use listed cable fittings. Listed Nonmetallic-Sheathed Cable fittings or integral box clamps are also suitable for use with Underground Feeder cable (Type UF) when connected to a box or enclosure above grade. Consult the manufacturer instructions to determine the specific wiring methods for which the fitting is intended and listed.

Type NM-B cable fittings are not intended for use in wet locations, direct burial in earth, embedment in poured concrete, or corrosive locations. Consult the fittings manufacturer for recommendations as to the need for supplementary protection in such locations.

8.4.1 Type NM-B Cable Connectors

Many nonmetallic boxes have built-in clamps, and separate cable connectors are not required. Connectors such as those shown in Figure 8.4.1 are used to connect NM-B cable to boxes or cabinets.

NOTE: Connectors having two screws to tighten the connector onto the cable are recommended. Some single-screw type connectors can pierce the cable sheath and conductor insulation.

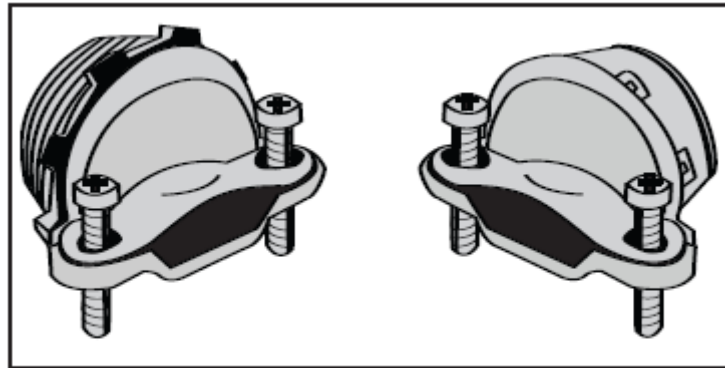


Figure 13: Type NM cable connectors

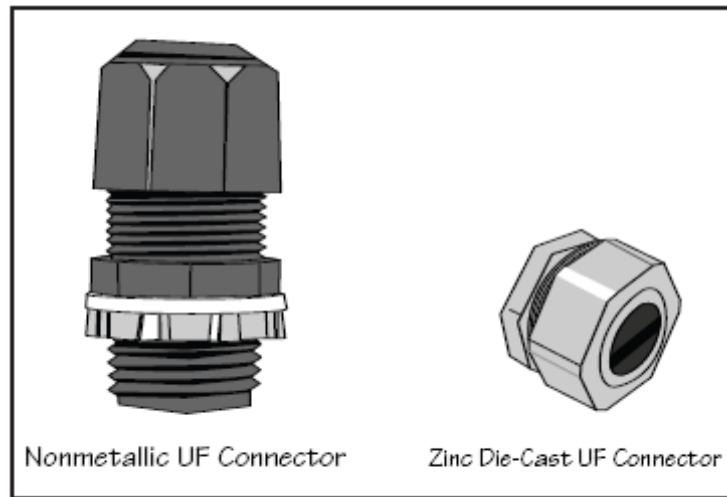
Figure 8.4.1: Type NM-B cable connectors

The size range of a listed NM cable fitting relates to the overall cross-sectional area of the cable. Refer to manufacturer instructions to determine whether a particular size cable is within the listed size range of a specific fitting. *NOTE: Fittings for use with NM cable might also make reference to traditional raceway trade sizes (e.g., 3/8, 1/2, 3/4), that typically refer to the knockout size in a box or enclosure into which the fitting is intended to be installed. Metric designators have been established that correspond to traditional trade sizes.*

1 All NM cable fittings employ a locknut or integral feature as a means for securement to a box or
 2 enclosure. Certain listed outlet and switch boxes are also provided with integral clamps, which are listed
 3 for use with NM cable.

6 **8.4.2 Type UF Cable Connectors**

7
 8 Type UF connectors are made in both metal and nonmetallic construction (see Figure 8.4.2).
 9



10
 11
 12 *Figure 8.4.2: Type UF cable connectors*
 13
 14

15 **8.5 Securing Cables to Metal Cabinets, Cutout Boxes, and Meter Sockets**

16 **8.5.1 Type NM-B and Type UF Cables**

17
 18 Cables must be secured to the cabinet, cutout box, or meter socket enclosure. Listed cable connectors
 19 must be used in accordance with the manufacturer instructions. Multiple cables may be used with
 20 connectors listed for use with more than one cable.
 21
 22

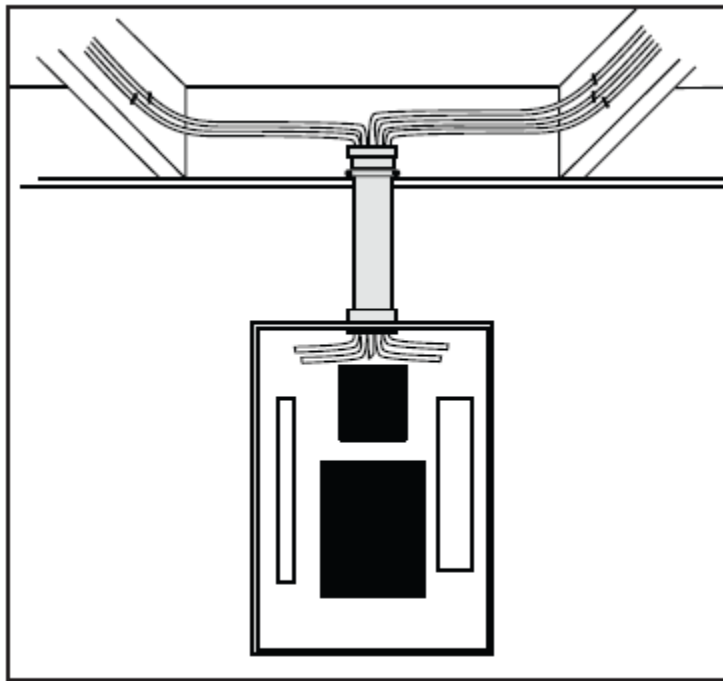
23 **8.5.2 Exception**

24
 25 In lieu of securing each Type NM-B and Type UF cables to the cabinet, cutout box, or meter socket
 26 enclosure, cables are permitted to enter the top of a surface-mounted enclosure through one or more
 27 nonflexible raceways not less than 450 mm (18 inches) and not more than 3 m (10 feet) in length,
 28 provided all of the following conditions are met (see Figure 8.5.2):
 29
 30

- 31 a) Each cable must be fastened within 300 mm (12 inches) of the outer end of the
 32 raceway.

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- b) The raceway must extend directly above the enclosure and must not penetrate a structural ceiling.
- c) A fitting must be provided on each end of the raceway to protect the cables from abrasion and the fittings remain accessible after installation.
- d) The raceway must be sealed at the outer end using approved means so as to prevent access to the enclosure through the raceway.
- e) The cable sheath must be continuous through the raceway and extend into the enclosure beyond the fitting and not less than 6 mm (1/4 inch).
- f) The raceway must be fastened at its outer end and at the other points in accordance with the applicable article.
- g) Where installed in conduit or tubing, the allowable cable fill does not exceed that permitted for complete conduit or tubing systems by Table 1 of Chapter 9 of the NEC and all applicable notes.



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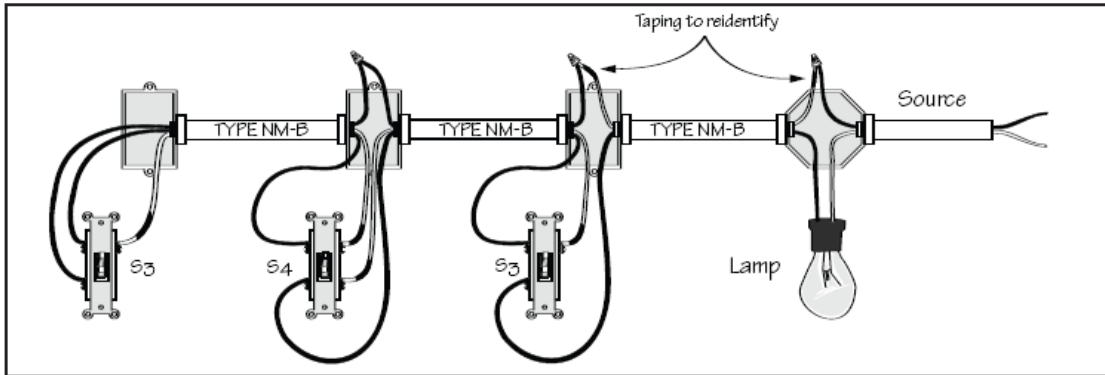
Figure 8.5.2: Alternate method to enter surface mounted cabinet

9. Re-identification of Conductors

9.1 Ungrounded Conductors

The use of a conductor with white insulation as other than a grounded conductor is permitted only where the insulation is permanently re-identified to indicate its use as an ungrounded conductor. Identification must be done by painting or other effective means at each location where the conductor is visible and

1 accessible. The identification must encircle the insulation and be of a color other than white, gray, or
 2 green (see Figure 9.1).
 3

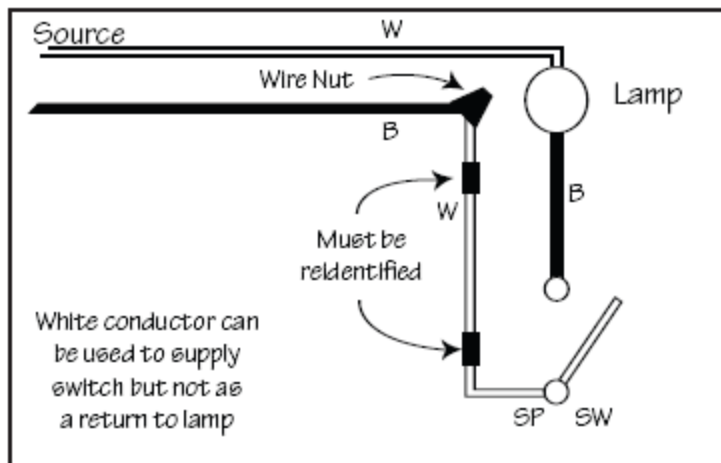


4
 5 *Figure 18: Conductor reidentification*

6 *Figure 9.1: Conductor re-identification*

7
 8
 9 **9.2 Switch Loops**

10 The white conductor in a nonmetallic-sheathed cable may be used as a supply to a single pole switch but
 11 not as a return conductor from the switch to the switched outlet to prevent two white conductors attached
 12 to the switched outlet. It is still necessary in this application to permanently re-identify the conductor with
 13 the white insulation (see Figure 9.2).
 14
 15

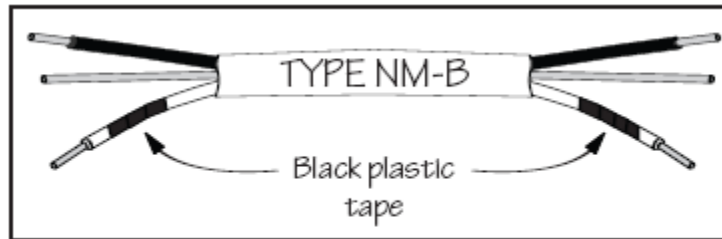


16
 17 *Figure 19: Switch leg identification*

18 *Figure 9.2: Switch leg identification*

19
 20
 21 **9.3 Permanently Re-identified**

1 The NEC does not designate what constitutes permanent re-identification other than painting or other
 2 approved means. Taping is most commonly used to re-identify conductors. Because the permanency of
 3 tape may be in question, verify that taping is acceptable to the AHJ (see Figure 9.3).
 4



5
6
7 *Figure 9.3: Switch leg identification*
8
9

10 9.4 Heat-Shrink Tubing

11
12 When possible, use heat-shrink tubing as a permanent method of re-identifying conductors. Slide a
13 minimum 150 mm (6 inch) length of heat-shrink tubing over the insulation of the conductor to be re-
14 identified. Apply heat in accordance with manufacturer instructions and shrink tubing tightly over the
15 conductor. *NOTE: Listed heat shrink tubing is available in packets containing assorted colors and sizes.*
16
17

18 10. Installation Procedures

19 10.1 Circuit Design Considerations

20
21 Existing installations using raceway wiring methods can be readily modified by adding conductors to the
22 raceways as needed. Cable-type wiring methods, such as Type NM-B and Type UF cable systems,
23 cannot be readily modified by adding conductors. It is recommended that Type NM-B and Type UF
24 cable systems be installed such that an unswitched ungrounded or phase conductor and the grounded or
25 neutral conductor are present in every box and enclosure to provide flexibility in making future circuit
26 modifications, such as the following:
27

- 28 • **Switch Outlets.** Replacing an existing snap switch with an electronic controller that
29 requires an unswitched ungrounded conductor and the grounded conductor for proper
30 operation. *NOTE: One method used by installers to accomplish this is by always feeding*
31 *the switch first, but together with this, a three-wire cable should be run to the lighting*
32 *outlet to ensure that an ungrounded conductor is available for use in any future*
33 *expansion where feeding a new outlet from the existing lighting outlet would be the most*
34 *logical manner.*
- 35 • **Ceiling Outlets.** For ceiling outlets where a combination fan/light may be installed in the
36 future, providing a four-wire cable will allow separate switching for the fan and the light
37 along with an unswitched ungrounded conductor and the grounded conductor at the
38 fan/light box.

- Three-way and Four-way Switches. Providing a four-wire cable at boxes containing three-way and four-way switches will provide an unswitched ungrounded conductor and a grounded conductor at each box.

10.1.1 Grounding

When grounding is required in accordance with the NEC, Type NM-B and Type UF cables must contain a separate equipment grounding conductor as part of its design to be able to safely carry ground current. The nonmetallic sheath of Type NM-B and Type UF cables is not a suitable for grounding purposes. Similarly, cable fittings for Type NM-B and Type UF cables are used solely for mechanical connection and effective closure of the box or enclosure at the cable entry. Fittings constructed of metal are considered bonded when assembled as intended to a properly grounded metal box or enclosure.

10.2 Underground Installations (Type UF Cable)

Type UF cable can be installed by direct burial in earth, or in raceways or enclosures where subject to physical damage; or where installed underneath buildings, driveways, or sidewalks. Type UF cable installed under a building must be installed in a raceway that extends beyond the outside walls of the building. Direct buried Type UF cable emerging from grade must be protected to a point at least 2.5 m (8 feet) above finished grade. A bushing or terminal fitting must be used at the end of a raceway where cables emerge from a direct burial wiring method.

Install direct-buried Type UF cable in accordance with the minimum cover requirements of NEC Table 300.5. See Annex A. For example, where used in residential branch circuits rated 120 volts or less with GFCI protection and maximum overcurrent protection of 20 amperes, direct-buried cable must have a minimum of 300 mm (12 inches) of cover. Where necessary to prevent physical damage to the cable, protection must be provided by suitable running boards or suitable sleeves. *NOTE: The use of a running board is generally accomplished by covering Type UF cable with sand fill and then placing a wooden board over the cable to prevent rocks or other coarse material or debris from damaging the cable.* Direct-buried Type UF cable not having ground-fault protection must be buried not less than 450 mm (18 inches).

10.3 Preparing Type NM-B and Type UF Nonmetallic-Sheathed Cable

Bends in Type NM-B and Type UF cables shall be so made that the cable is not damaged. The radius of the curve of the inner edge of any bend during or after installation must not be less than five times the diameter of the cable.

Type NM-B cable is easily installed and few tools are required. Suitable cutting tools, such as lineman's pliers, are used to cut the cable to length (See Figure 10.2.1). Once the cable is cut to length, at least 150 mm (6 inches) of the jacket must be removed using a suitable tool, such as cable rippers, before inserting into the outlet box. Cable rippers have a small, razor sharp blade, that will only penetrate and cut the cable outer jacket.

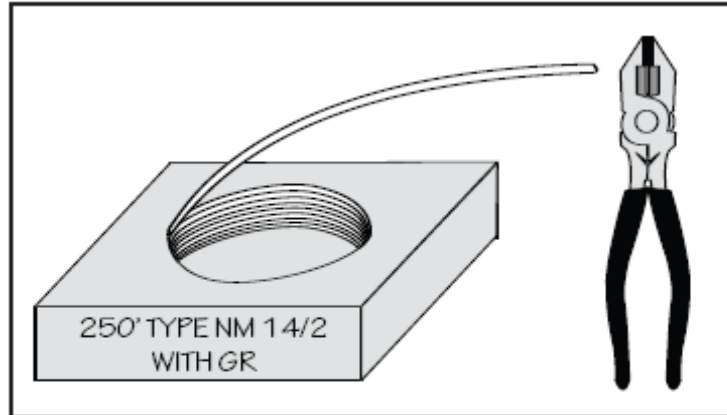


Figure 21: Using linemans pliers to cut NM cable

Figure 10.2.1: Using lineman's pliers to cut cable

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4
5 Secure cables to outlet boxes using suitable cable connectors. The cable connectors can be either the
6 external type as shown in Figure 8.4.1, internal connectors mounted in the box, or tabs that are an integral
7 part of a nonmetallic outlet box. Where a 57 mm x 100 mm (2-1/4 inch x 4 inch) nonmetallic box is used,
8 securing to the outlet box is not necessary as shown in Figure 8.3.1.
9

10 Follow cable manufacturer instructions in preparing cables for installation. Secure cable fittings to boxes
11 and enclosures before installing cables. Fasten the fitting to the box or enclosure and the locknut, when
12 part of the fitting's design, and secure hand tight. Do not apply excessive torque to the fitting's
13 securement screws. After securing the fitting to the box or enclosure, insert the cable into the cable entry
14 of the fitting or box clamp through the opening provided in the box. Exercise caution when installing
15 cables to not damage individual conductor insulation or to cut, puncture, or otherwise damage the cable
16 sheath. Ensure that a sufficient working length of the cable is fed into the box or enclosure to permit
17 cable preparation outside the face of the box in accordance with NEC Section 300.14. Each conductor
18 must be long enough to extend at least 75 mm (3 inches) beyond the face of the box.
19

20 Carefully prepare cables and conductors for termination. Measure and remove the required length of
21 cable outer sheath to expose individual conductors. Do not cut or scar the insulation on individual
22 conductors when stripping the outer sheathing of the cable.
23

24 Position the cut end of the cable sheath so that a minimum of 6 mm (1/4 inch) extends beyond the exit end
25 of the cable fitting or box clamp. If necessary, rotate the cable to ensure the clamp will effectively seat on
26 a flat surface of the cable sheath when finally secured. For a round-shaped cable, apply gentle pressure
27 between the thumb and index finger to separate conductors and slightly flatten the cable at the location of
28 the fitting prior to tightening.
29

30 Use torque-indicating tools to assembly cable fittings. Exercise care during the final tightening of the
31 cable-holding device not to cut, puncture, or otherwise damage the cable sheathing or conductor
32 insulation. Tighten fittings to manufacturer recommended levels. In the absence of manufacturer
33 recommendations, tighten cable-holding devices to 1.7-2.3 N•m (15-20 lb-in.).
34

1 Terminate conductors to terminals and equipment in accordance with manufacturer instructions. See
2 NECA 130 and NECA 169 for connections to wiring devices, AFCIs, and GFCIs.

3
4
5 **10.4 Final Installation Checks**

6
7 Perform insulation resistance testing on conductors prior to terminating conductors in accordance with
8 manufacturer instructions.

9
10 Verify that conductors, cables, and cable assemblies are properly secured and supported. Verify that
11 conductors, cables, and cables assemblies are terminated and supported at panelboards, boxes, and
12 devices. Verify that conductor ampacity is not less than the ampere rating of the circuit unless otherwise
13 permitted for specific types of utilization equipment. Verify that splices and taps are made in a code-
14 compliant manner.

15
16 Check the tightness of fittings, locknuts, clamps, and supports. Verify that screws are not stripped.
17 Replace damaged or defective components.

18
19 Verify that conductors, cables, and cable assemblies show no evidence of overheating or deterioration.
20 Verify that conductors, cables, and cable assemblies show no evidence of fraying, damage, or physical
21 abuse. Verify that the cable sheath is not cut or overstretched. Verify that individual conductors are not
22 cut, scraped, or otherwise damaged. Remove and replace damaged or defective conductors, cables, and
23 cable assemblies.

24
25 Check, conductors, cables, and cable assemblies for evidence of exposure to water or moisture. Replace
26 any conductor, cable, cable assembly, or fitting listed only for dry locations, such as Type NM-B cable,
27 that has been exposed to water. See NEMA's Evaluating Water-Damaged Electrical Equipment.

28
29 Test wiring devices in accordance with NECA 130. Test AFCI and GFCI devices in accordance with
30 NECA 169. Correct any wiring discrepancies found.

1 *(This annex is not part of the Standard)*
2
3

4 **Annex A: Tables**
5

6 Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment
7
8

9 *(Insert Table Here)*
10
11

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13 National Fire Protection Association, Quincy, MA. This reprinted material is not the complete and official
14 position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.
15
16

NECA 121

1 Table 300.5 Minimum Cover Requirements, 0 to 1000 Volts, Nominal, Burial in Millimeters (Inches)

2

3 *(Insert Table Here)*

4

5

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9

10

11

NECA 121

1 Table 310.15(B)(2)(a) Ambient Temperature Correction Factors Based on 30°C (86°F)

2

3 *(Insert Table Here)*

4

5

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9

10

11

NECA 121

1 Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors in a
2 Raceway or Cable

3
4 *(Insert Table Here)*

5
6
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10
11
12

NECA 121

1 Table 310.15(B)(3)(c) Ambient Temperature Adjustment for Raceways or Cables Exposed to Sunlight on
2 or Above Rooftops

3
4 *(Insert Table Here)*

5
6
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10
11
12

NECA 121

1 NEC Table 310.15(B)(16) Allowable Ampacities of Insulated Conductors Rated Up to and Including
2 2000 Volts, 60°C Through 90°C (140°F Through 194°F), Not More Than Three Current-Carrying
3 Conductors in Raceway, Cable, or Earth (Directly Buried), Based on Ambient Temperature of 30°C
4 (86°F) (Courtesy National Fire Protection Association)
5

6 *(Insert Table Here)*
7
8

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12

1 *(This annex is not part of the Standard)*
 2
 3

4 **Annex B: Ampacity Adjustment and Correction Factor** 5 **Calculations**

7 **B.1 General**

8
 9 In accordance with the NEC, the allowable ampacity of Type NM-B and Type UF power conductors is
 10 limited that of a 60°C (140°F) rated conductor using NEC Table 310.15(B)(16).
 11

12 For ampacity adjustment and correction calculations, the 90°C (194°F) rating is permitted to be used for
 13 conductors so rated, provided the final derated conductor ampacity does not exceed that of a 60°C
 14 (140°F) rated conductor.
 15

16 Conductor ampacity is adjusted when there are more than three current-carrying conductors in a raceway
 17 or cable, and when raceways or cables are exposed to sunlight on rooftops. Ampacity must be corrected
 18 when the ambient temperature differs from the nominal temperature in the conductor ampacity table.
 19
 20

21 **B.2 Ampacity adjustment for more than three current-carrying conductors in a raceway**

22
 23 Maintaining the spacing between current-carrying conductors is important because it allows heat to
 24 dissipate. Where Type NM-B and/or Type UF cables are grouped together without maintaining spacing,
 25 the ampacities of the current-carrying conductors must be adjusted based on the number of current-
 26 carrying conductors in close proximity in accordance with the ampacity adjustment factors found in NEC
 27 Table 310.15(B)(2)(a) (see Annex A). Ampacity adjustment is required when Type NM-B and/or Type
 28 UF cables are bundled or are stacked together without providing the spacing necessary for the heat to
 29 dissipate naturally. See Section 7.1.
 30

31 ***B.2.1 Sample Calculations***

32
 33 To determine the allowable ampacity of multiconductor cables that are stacked or bundled together, it is
 34 necessary to determine the number of conductors that are considered to be current-carrying conductors in
 35 accordance with the NEC. Using 12/3 Type NM-B or Type UF cable (plus ground), for example, each
 36 cable has two ungrounded or phase conductors, one grounded or neutral conductor, and one equipment-
 37 grounding conductor.
 38

39 Ungrounded or Phase Conductors. All ungrounded or phase conductors are included in the count
 40 of current-carrying conductors. The only exception is when not all of the current-carrying
 41 conductors carry current simultaneously, such as when switching or controls divert the current
 42 from one conductor to another.
 43

44 Grounded or Neutral Conductors. The grounded or neutral conductor is not counted unless it is
 45 the common conductor in a three-wire circuit consisting of two phase conductors and the neutral
 46 of a three-phase, four-wire, wye-connected system in accordance with NEC Section

NECA 121

1 310.15(B)(5)(b). Conversely, the common neutral conductor for a three-wire circuit connected to
2 a 240/120 volt three-wire, single-phase system is not included in the count of current-carrying
3 conductors.
4

5 Equipment Grounding Conductors. Because the equipment-grounding conductor is not intended
6 to carry current under steady-state conditions, it is not included in the count of current-carrying
7 conductors.
8

9 When two 12/3 Type NM-B and/or Type UF cables supplied from a 240/120 Volt three-wire, single-
10 phase system are bundled or stacked together, there are a total of four current-carrying conductors (four
11 ungrounded conductors are included in the count of current-carrying conductors, while the two neutral
12 conductors and two equipment grounding conductors are not included).
13

14 The ampacity of the current-carrying conductors is adjusted in accordance with NEC Table
15 310.15(B)(2)(a), which indicates that, for four to six current-carrying conductors in close proximity, the
16 ampacity of the current-carrying conductors is reduced to 80 percent. Recalling that the NEC permits
17 derating from the 90°C rated column for conductors so rated, the ampacity of 12 AWG copper conductors
18 in the 90°C rated column in NEC Table 310.15(B)(16) is 30 Amperes. Derating 30 Amperes to 80
19 percent results in an ampacity of 24 Amperes for these conductors, which is greater than the 60°C
20 ampacity of the conductor (20 Amperes) which cannot be exceeded for Type NM-B and Type UF cables.
21

22 Of particular note is that NEC Section 240.4(D) limits the overcurrent protection of certain small
23 conductors (18 AWG through 10 AWG) under certain applications. Unless installed as tap conductors for
24 specific installations (NEC Section 240.4(E)), or for specific conductor applications (NEC Section
25 240.4(G)), such as for control and instrumentation circuit conductors and for motor and motor-control
26 circuit conductors, overcurrent protection for 12 AWG copper conductors is limited to 20 Amperes after
27 applying any correction factors for ambient temperature or adjustment factors for the number of
28 conductors.
29

30 Derating using the 90°C rated column for conductors so rated permits the use of 20 Ampere overcurrent
31 protective devices for 12 AWG copper conductors up to the point where there are 10 to 20 current-
32 carrying conductors in close proximity. With an adjustment factor of 50 percent, 10 to 20 current-
33 carrying 12 AWG copper conductors would have an ampacity of 15 Amperes, which would require
34 overcurrent protection of not more than a 15 Amperes in accordance with NEC Section 240.6
35

36 In short, using not more than nine current-carrying 12 AWG copper conductors in close proximity permits
37 the use of 20 Ampere overcurrent protective devices for conductors with insulation rated 90°C. Avoid
38 bundling or stacking for a distance more 600 mm (24 inches), which could result in more than nine
39 current-carrying conductors in close proximity, requiring an ampacity adjustment factor of 50 percent or
40 more.
41

42 Additionally, where more than two cables containing two or more current-carrying conductors pass
43 through the same opening in wood framing that is to be fire or draft stopped using thermal insulation,
44 caulk, or sealing foam, or if the conductors are installed in contact with thermal insulation without
45 maintaining spacing between cables, the allowable ampacity of each conductor shall be adjusted in
46 accordance with NEC Table 310.15(B)(2)(a). Note there is no 600 mm (24-inch) provision in this
47 requirement.
48

1 Table B.2.1.1, below, indicates that the use of 90°C rating of the conductors for ampacity-derating
 2 purposes will many times result in the final overcurrent protection permitted being consistent with the
 3 requirements of NEC 240.4(D).
 4

5 **Table B.2.1.1: Using 90°C Rated Conductors for Ampacity Adjustment for More Than Three**
 6 **Current-Carrying Conductors in Close Proximity.**
 7

Cable Size	Current-carrying Conductors	310.15(B)(3)(a) Adjustment %	Table 310.15(B)(16) 60° Column	Derated Ampacity	Table 310.15(B)(16) 90° Column	Derated Ampacity	Overcurrent Permitted 240.4(D)
(2) 14-3 w/gr	4	80	15	16	25	20	15
(3) 14-3 w/gr	6	80	15	16	25	20	15
(4) 14-3 w/gr	8	70	15	14	25	17.5	15
(2) 12-3 w/gr	4	80	20	20	30	24	20
(3) 12-3 w/gr	6	80	20	20	30	24	20
(4) 12-3 w/gr	8	70	20	17.5	30	21	20
(2) 10-3 w/g	4	80	30	24	40	32	30
(3) 10-3 w/g	6	80	30	24	40	32	30

8
 9
 10 **B.3 Correction factors for ambient temperature**

11
 12 The ampacity of Type NM-B and Type UF cable must be adjusted based upon ambient temperature
 13 correction factors in accordance with NEC Table 310.15(B)(2)(a). The correction factor is applied to the
 14 ampacity given by NEC Table 310.15(B)(16) to determine the conductor ampacity.
 15

16 **B.3.1 Sample Calculations**

17
 18 To determine the allowable ampacity of Type NM-B and Type UF cable conductors that are installed in
 19 an environment with an ambient temperature other than 30°C (86°F).
 20

21 For a cable installed within an attic space with an ambient temperature of 55°C (131°F), the ampacity
 22 adjustment factor for a 90°C rated conductor from NEC Table 310.15(B)(2)(a) is 0.76. For a 90°C rated
 23 12 AWG copper conductor, the ampacity is 30 Amperes. Applying a 0.76 ampacity adjustment factor to
 24 30 Amperes results in an adjusted ampacity of 22.8 Amperes, which is required to be protected by a 20
 25 Ampere overcurrent protective device in accordance with NEC Section 240.4.
 26
 27

28 **B.4 Ampacity adjustment for rooftop installations**

29
 30 *NOTE: Type NM-B cable is not permitted to be installed in a wet environment, such as on a rooftop.*
 31 *Type UF cable is permitted to be installed exposed, outdoors, such as on a rooftop, provided it is listed as*
 32 *sunlight resistant.*
 33

34 The ampacity of roof-mounted Type UF cable conductors must include an additional ambient temperature
 35 correction factor in accordance with NEC Table 310.15(B)(3)(c) (see Annex A) to accommodate the
 36 reflected and radiated heat associated with exposure to sunlight for roof-top installations in accordance

1 with NEC Section 310.15(B)(3)(c). The adjustment factor from Table 310.15(B)(3)(c) must be added to
2 the outdoor temperature at the installation location to determine the applicable ambient temperature for
3 application of the correction factors in Table 310.15(B)(2)(a). *NOTE: One source for the ambient*
4 *temperatures (design conditions) in various locations is the ASHRAE Handbook — Fundamentals.*
5

6 ***B.4.1 Sample Calculations***

7
8 To determine the allowable ampacity of Type UF cable conductors that are exposed to sunlight for
9 rooftop installations, it is necessary to determine the cable installation height above the rooftop.

10
11 For a roof-mounted cable that is installed on blocks or stands approximately 64 mm (2-1/2) inches above
12 the surface of the roof, an ambient temperature adjustment factor of 28°C (50°F) from NEC Table
13 310.15(B)(3)(c) is added to the ambient temperature adjustment factors from NEC Table 310.15(B)(2)(a).
14

15 Using NEC Table 310.15(B)(2)(a) (for 30°C (86°F) ambient temperature ampacity tables), add the
16 ambient temperature adjustment factor from NEC Table 310.15(B)(3)(c) to the expected ambient to
17 determine the adjustment factor for ampacity.
18

19 For example, using NEC Table 310.15(B)(2)(a) (for 30°C (86°F) ambient temperature ampacity tables),
20 an ambient outdoor (design condition) temperature of 43°C (110°F) at a given location, and an installation
21 height of approximately 64 mm (2-1/2) inches above the rooftop for Type UF cable, the temperature
22 adjustment factor of 28°C (50°F) is added to the outdoor ambient (design) temperature to determine the
23 temperature adjustment factor. For an adjusted temperature of 71°C (160°F) comprised by adding the
24 ambient outdoor (design condition) temperature and the temperature adjustment factor from NEC Table
25 310.15(B)(3)(c), the ampacity adjustment factor for a 90°C rated conductor from NEC Table
26 310.15(B)(2)(a) is 0.50.
27

28 For a 90°C rated 12 AWG copper conductor, the ampacity is 30 Amperes. Applying a 0.50 ampacity
29 adjustment factor to 30 Amperes results in an adjusted ampacity of 15 Amperes, which is required to be
30 protected by a 15 Ampere overcurrent protective device in accordance with NEC Section 240.4.
31
32
33
34

1 (This annex is not part of the Standard)
2
3

4 **Annex C: Reference Standards**

5

6 This publication, when used in conjunction with the National Electrical Code® and product manufacturer
7 literature, provides sufficient information to install and maintain nonmetallic-sheathed cable (Type NM)
8 and underground feeder and branch-circuit cable (Type UF). The following publications may also
9 provide useful information:

10
11 American Society of Heating, Refrigerating and Air-Conditioning Engineers
12 1791 Tullie Circle, N.E.
13 Atlanta, GA 30329
14 (800) 527-4723 tel (U.S. and Canada only)
15 (404) 636-8400 tel
16 (404) 321-5478 fax
17 www.ashrae.org
18

19 *ASHRAE Handbook — Fundamentals*
20

21
22 National Fire Protection Association
23 1 Batterymarch Park
24 P.O. Box 9101
25 Quincy, Massachusetts 02269-9101
26 (617) 770-3000 tel
27 (617) 770-3500 fax
28 www.nfpa.org
29

30 NFPA 70-2014, *National Electrical Code* (ANSI)

31
32 NFPA 70E-2004, *Standard for Electrical Safety in the Workplace*

33
34 NFPA 220, *Standard on Types of Building Construction*
35

36
37 National Electrical Manufacturers Association
38 1300 North 17th Street
39 Suite 900
40 Arlington, Virginia 22209
41 (703) 841-3200 tel
42 www.nema.org
43

44 NEMA 250-2014, *Enclosures for Electrical Equipment (1000 Volts Maximum)*

45
46 NEMA's *Evaluating Water-Damaged Electrical Equipment*.
47

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