Standard for Good Workmanship in Electrical Construction

NECA 1-2010
Standard for

Good Workmanship in Electrical Construction

An American National Standard

Published by
National Electrical Contractors Association

Standard for Good Workmanship in Electrical Construction

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Revision History

NECA 1-2000	03/2000
NECA 1-2006	08/2006
NECA 1-2010 (Reaffirmation)	01/2011

(This foreword is not a part of the standard.)

Foreword

National Electrical Installation Standards™ (NEIS®) are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. NEIS are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

General work practices for electrical construction shall be in accordance with NECA 1-2010, *Standard for Good Workmanship in Electrical Construction* (ANSI).

Foreword (continued)

Use of *NEIS* is voluntary, and the National Electrical Contractors Association (NECA) assumes no obligation or liability to users of this publication. Existence of a standard shall not preclude any member or nonmember of NECA from specifying or using alternate construction methods permitted by applicable regulations.

This publication is intended to comply with the edition of the *National Electrical Code (NEC)* in effect at the time of publication. Because they are quality standards, *NEIS* may in some instances go beyond the minimum safety requirements of the *NEC*. It is the responsibility of users of this publication to comply with state and local electrical codes when installing electrical products and systems.

Foreword (continued)

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

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Foreword (continued)

To purchase *NEIS*, contact the NECA Order Desk at (301) 215-4504 tel, (301) 215-4500 fax, or orderdesk@ necanet.org. NEIS can also be purchased in .pdf download format at *www.neca-neis.org/standards*.

Foreword (continued)

Photos and illustrations courtesy of the International Association of Electrical Inspectors (IAEI).

1. Scope

This standard describes what is meant by installing equipment in a "neat and workmanlike manner" as required by the *National Electrical Code*, Section 110.12.

1.1 Regulatory and Other Requirements

a) All information in this publication is intended to conform to the *National Electrical Code* (ANSI/NFPA 70). Installers should always follow the *NEC*, applicable state and local codes, manufacturer's instructions, and contract documents doing installations.

1. Scope (continued)

1.1 Regulatory and Other Requirements (continued)

b) Only qualified persons familiar with the construction and installation should perform the work described in this publication. It is recommended that all work be performed in accordance with NFPA 70E, *Standard for the Electrical Safety in the Workplace.*

c) Other *National Electrical Installation Standards (NEIS)* provide additional guidance for installing particular types of electrical products and systems. A complete list of *NEIS* is provided in Annex A.

2. Receiving, Storing and Protecting

2.1 Receiving Material on Site

a) Material and equipment shall be carefully unloaded, observing all packing label warnings.

b) Packages with packing slips and/or purchase orders shall be inventoried. Back orders shall be documented and new shipping schedules verified. If approved project data (shop drawings) are used, check all products for completeness and timely delivery. Expedite or otherwise resolve the product delivery schedule problems.

2. Receiving, Storing and Protecting (continued)

2.1 Receiving Material on Site (continued)

c) Leaving protective coverings in place as much as possible, shipment shall be opened and inspected completely and, as quickly as possible, recovery of loss due to shipping damage shall be initiated. Undamaged material shall be carefully repacked, unless intended for immediate installation. *NOTE: Depending on specifications, company policy or project circumstances, it may be necessary to receive, unpack and check all material at the company shop or other staging area, in which case careful repackaging is essential.*

2. Receiving, Storing and Protecting (continued)

2.2 Storage and Protection

a) Material shall be stored in a clean, dry and secure location. Especially avoid spaces were water might accumulate or where significant airborne dust or dirt is present. If such a location is not available, material shall be stored on pallets or other means to rise above floor and possible water levels, and wrapped in protective plastic sheeting.

2. Receiving, Storing and Protecting (continued)

2.2 Storage and Protection (continued)

b) Observing warnings and stacking instructions on packaging or shipping materials, equipment shall be stacked or otherwise stored to prevent damage.

c) Storage shall be organized with essential information such as luminaire type, project destination, voltage, job tags, or labels for easy reference and access.

d) Boxes that are partially crushed shall not be stacked even if the products are intact.

2. Receiving, Storing and Protecting (continued)

2.2 Storage and Protection (continued)

e) Should any event, such as a water leak, occur that could damage stored material, the affected material shall be re-inspected for damage and necessary replacements shall be obtained.

f) Apparatus with moisture-sensitive insulation, such as dry-type transformers, shall be stored under conditions that ensure the insulation material does not
absorb moisture. For example, relative humidity must be maintained below 75% at all times.

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3. General Requirements

Good workmanship shall be apparent in the installation of all electrical materials and equipment, as in the photo below.

a) Equipment shall be level, plumb and true with the structure and other equipment; also in a horizontal or vertical position as intended.

3. General Requirements (continued)

b) All materials shall be firmly secured in place, adequately supported, and permanent. Materials embedded in concrete or masonry or otherwise part of the structure are considered sufficiently supported.

c) All hardware, fittings, and accessories shall be of a type designed, intended and appropriate for use and complement the items with which they are used.

3. General Requirements (continued)

d) All materials and equipment including hangers, supports, fasteners or fittings, and accessories shall have corrosion protection suitable for the atmosphere in which they are installed (whether located indoors or outdoors). Care shall be taken during the installation to assure the integrity of the corrosion protection. Damaged corrosion protection shall be repaired during or after installation.

3. General Requirements (continued)

e) All screws, bolts, nuts, clamps, fittings or other fastening devices shall be made up tight in accordance with manufacturers' and/or listing instructions.

f) Plans and specifications shall be carefully followed when installing equipment. *NOTE: Local building codes may have seismic requirements that affect equipment installation. Installers shall consult these codes or coordinate with the general contractor prior to installing equipment.*

4. Anchors and Fasteners

Permanence and neat appearance, a part of good workmanship, require that consideration be given to the type of atmosphere surrounding anchors and fasteners. Anchors and fasteners shall be non-corrosive or have adequate corrosion resistant coatings or treatment. Weather conditions must be considered for outdoor locations, but there are also indoor locations that may be wet or damp. Fumes from industrial processing also may cause corrosive atmospheres. The possibility of corrosion due to electrolytic action between dissimilar metals must also be considered. Corrosion and deterioration is addressed in Section 300.6 of the *NEC*.

4. Anchors and Fasteners (continued)

a) All anchors and fasteners shall be of a type designed for the purpose and rated capable of adequately and safely securing the item on the base material in which the anchor or fastener is used. Selection shall be based on the amount and type of load, base material, safe working load and atmosphere.

4. Anchors and Fasteners (continued)

b) In addition to the weight of the material, consideration should also be given to vibration, such as with motors or fans; variable loading resulting from internal or external forces, such as operation of safety switches or circuit breakers; and shock load, when possible, as shown.

4. Anchors and Fasteners (continued)

c) Anchors or fasteners used shall be a type designed and intended for use in the base material to which the material or support is to be attached. Generally, screws are used on wood, masonry anchors on concrete or brick, toggle bolts or similar on hollow walls, machine screws, bolts or welded studs on steel. Nails are normally used only for temporary support or for light loads, such as nonmetallic outlet and device boxes, in wood frame construction.

5. Hangers and Supports

The weight of the hanger or support must be considered as part of the total load. The total load also includes the materials within an enclosure. For example, the weight of the conductors in a raceway or junction or pull box shall be added to the load of the raceway or box. External forces such as vibration, operation of equipment, such as switch handles, or possible shock load shall also be considered.

Safe working load shall be determined by applying recognized safety factors to the rated strength of the complete assembly and shall be based on the weakest component member.

5. Hangers and Supports (continued)

a) Hangers and supports shall be used to properly and firmly support electrical materials or equipment in a safe and permanent manner. They may be standard manufactured items or fabricated in the shop or on the job site, as the photo shows.

b) They shall be of a type designed or appropriate for the purpose, have a neat and finished appearance and complement the installation.

5. Hangers and Supports (continued)

c) Job fabricated hangers and supports shall be made from standard structural shapes and hardware or systems of shapes, fittings and hardware designed for the purpose. One example would be angle irons.

d) All bolts, screws, nuts, and other threaded devices shall have standard threads and heads so that they do not require special tools and may be readily replaced when necessary unless required for tamper-proof installation.

e) All threads shall be fully engaged (or covered) and all parts made up tight.

5. Hangers and Supports (continued)

f) The selection of hangers and supports shall be based on the following criteria:

1. Amount and type of load
2. Safe working load
3. Atmosphere
4. Manufacturers' recommendations
5. Job specifications
6. Listing for the application (where applicable)
7. Spacing intervals required by the *NEC* (where applicable).

5. Hangers and Supports (continued)

g) Hangers and supports, whether standard manufactured items or job fabricated, shall have corrosion protection suitable for the atmosphere in which they are installed (whether located indoors or outdoors). Care shall be taken during the installation to assure the integrity of corrosion protection. Damaged corrosion protection shall be repaired during or after installation.

h) When hangers and supports that have corrosion protection are field cut, the material shall be protected by field application of an approved zinc-enriched
paint or similar sealant in accordance with 300.6.

5. Hangers and Supports (continued)

i) Care must be taken to prevent corrosion that might result from the use of dissimilar metals in damp or wet locations. Damaged corrosion protection coatings shall be repaired during or after installation.

j) Hangers and supports shall be adequately and safely attached to the building structure or structural member.

k) The equipment or materials to be supported shall be securely fastened to the supporting means with material suitable for the purpose.

6. Outlet Boxes

a) Outlet and device boxes shall be of a type designed for the use and location, as in the photo below.

b) Outlet and device boxes shall be securely and rigidly attached or supported plumb, level, and true.

6. Outlet Boxes (continued)

c) Box supports, hangers or brackets, when used, shall be of a type designed or suitable for the type of box used and the building structural member to which they are attached. In determining the type of support or fastener, consider the total load caused by any device or equipment, such as lighting fixtures, which are in turn supported by the outlet box, as shown.

6. Outlet Boxes (continued)

d) Outlet and device boxes and their covers shall have corrosion protection suitable for the atmosphere in which they are installed. Where necessary, gaskets shall be used to prevent the entrance of moisture.

e) Installation of outlet and device boxes shall be coordinated with other trades, such as drywall and painting.

f) Outlet and device boxes shall be protected to prevent entrance of foreign matter. Plaster and debris shall be thoroughly cleaned from the box before the conductors are installed.

6. Outlet Boxes (continued)

g) Generally, single-gang outlet and device boxes for switches shall be mounted with the long axis vertical.

h) Generally, boxes for receptacles shall be mounted either vertically or horizontally, but consistently throughout the structure.

i) Boxes of three or more gangs shall be mounted with the long axis (dimension) horizontal. The boxes shall be located so that the cover or device plate will not span different types of building finishes either vertically or horizontally.

6. Outlet Boxes (continued)

j) Boxes for switches near doors shall be located on the side opposite the hinge and close to the door trim.

k) Covers for outlet boxes shall be of a type designed, intended and appropriate for the use and location, and have suitable corrosion protection. Plastic device plates shall not be used as covers for surface mounted boxes.

7. Junction and Pull Boxes

a) Junction and pull boxes shall be used where necessary to facilitate the pulling of wire or cable. Section 314.28(A) in the *NEC* provides minimum sizing requirements for junction or pull boxes used in wiring systems containing conductors in sizes 4 AWG and larger.

b) Consideration shall be given to the size and number of conductors, number of bends in the raceway, and the need for support of conductors in vertical raceways.

7. Junction and Pull Boxes (continued)

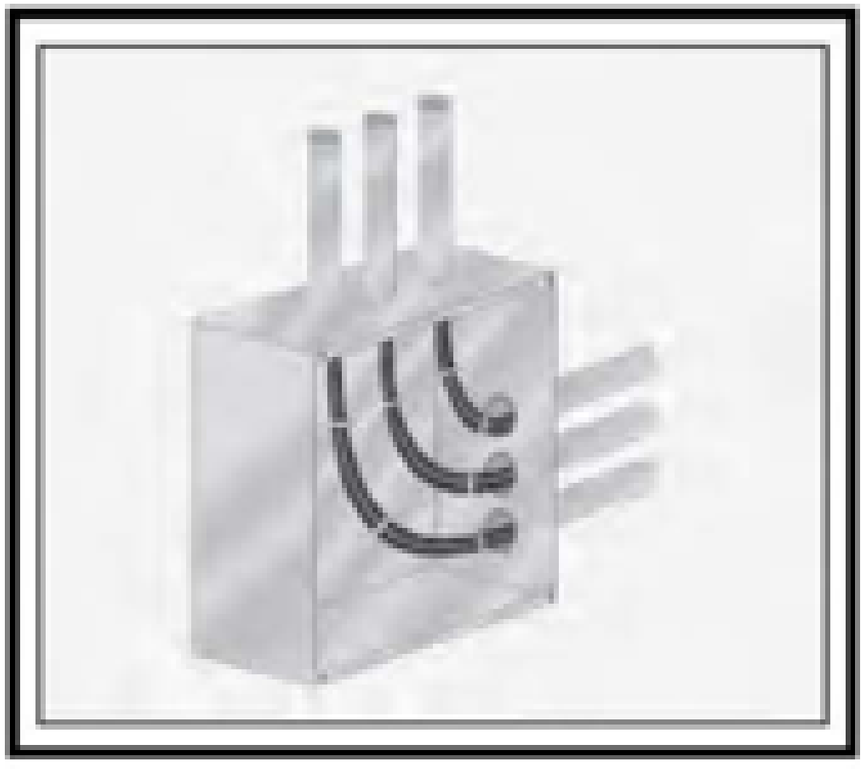
c) Junction and pull boxes shall be of a type intended or suitable for the use and location. They may be standard manufactured items or custom designed and fabricated to meet the particular requirements.

d) Junction and pull boxes including hinges or screws used to fasten the cover shall have corrosion protection suitable for the atmosphere in which they are installed.

7. Junction and Pull Boxes (continued)

e) Junction and pull boxes shall be firmly and securely fastened to or supported from the building structure or structural member. In determining the type of fastener, hanger, or support, consideration must be given to the load caused by any conductors supported by the box and any load that might be caused by external forces.

f) Raceways shall be arranged to provide the longest sweep or radius for the conductors, as shown in the photo.



7. Junction and Pull Boxes (continued)

g) Covers for large junction or pull boxes that are that are 1.8 m^2 (6 ft^2) or larger should be hinged or sectionalized to facilitate removal and replacement. When the cover is sectionalized, cross bracing shall be provided to fasten the sections of the cover at the seams.

8. Raceways

a) Raceways shall be firmly and securely fastened to or supported from the building structure or a structural member or embedded in concrete or masonry. Tables 1a and 1b (on the next two slides) list recommended spacing of supports for vertical and horizontal raceways.

b) Hangers and supports shall be of a type compatible with and suitable for the intended use. They may be standard manufactured items or job fabricated. Consideration must be given to the weight of the enclosed conductors when selecting supports and fastening means.

8. Raceways

(continued)

Table 1a: Spacing of Conduit Supports*

Conduit Trade Size (inches)	No. of Conductors in Run	Location	Maximum Support Spacing (feet)
		HORIZONTAL RUNS	
½	1 or 2	Flat ceiling or wall	5
½	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction	7
½	3 or more	Any location	7
1 and larger	1 or 2	Flat ceiling or wall	6
1 and larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction	10
1 and larger	3 or more	Any location	10
Any	…	Concealed	10

8. Raceways

(Table 1a continued)

VERTICAL RUNS			
⅜, ½	…	Exposed	7
1, 1¼	…	Exposed	8
1½ and larger	…	Exposed	10
Up to 2	…	Shaftway	14
2½ and larger	…	Shaftway	28
Any	…	Concealed	10

1. A support shall be provided for exposed or concealed raceway as close as practical to and not exceeding one foot from an unsupported box or access fitting. In horizontal runs, a support at a box or access fitting may be omitted when the box or access fitting is independently supported and the raceway terminal is not made with a Chase nipple or threadless box connector.
2. In vertical runs, the load produced by the weight of the raceway and the enclosed conductors shall not be carried by the raceway terminals but shall be carried entirely by the conduit supports.

* (The National Electrical Code did not provide specific requirements for the support of rigid metal conduit until the 1965 Edition. The table of spacings in the Code applied to sizes 1/2" through 3" only and was expanded to cover up to 6" in the 1968 Edition. The spacing requirements of this standard were originally published by the National Electrical Contractors Association in 1928 as part of the "Electragist Standards for Wiring Installations." They have been frequently quoted and included in handbooks on electrical installations. In some specifics they are more restrictive than the requirements of the National Electrical Code.)

8. Raceways

(continued)

Table 1b: Spacing of Conduit Supports*

Conduit Trade Size (metric designator)	No. of Conductors in Run	Location	Maximum Support Spacing (meters)
		HORIZONTAL RUNS	
16, 21	1 or 2	Flat ceiling or wall	1.5
16, 21	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction	2.1
16, 21	3 or more	Any location	2.1
27 and larger	1 or 2	Flat ceiling or wall	1.8
27 and larger	1 or 2	Where it is difficult to provide supports except at intervals fixed by the building construction	3
27 and larger	3 or more	Any location	3
Any	...	Concealed	3

8. Raceways

(Table 1b continued)

		VERTICAL RUNS	
16, 21	…	Exposed	2.1
27, 35	…	Exposed	2.5
41 and larger	…	Exposed	3
Up to 53	…	Shaftway	4.3
63 and larger	…	Shaftway	8.5
Any	…	Concealed	3

1. A support shall be provided for exposed or concealed raceway as close as practical to and not exceeding one foot from an unsupported box or access fitting. In horizontal runs, a support at a box or access fitting may be omitted when the box or access fitting is independently supported and the raceway terminal is not made with a Chase nipple or threadless box connector.
2. In vertical runs, the load produced by the weight of the raceway and the enclosed conductors shall not be carried by the raceway terminals but shall be carried entirely by the conduit supports.

* (The National Electrical Code did not provide specific requirements for the support of rigid metal conduit until the 1965 Edition. The table of spacings in the Code applied to sizes 1/2" through 3" only and was expanded to cover up to 6" in the 1968 Edition. The spacing requirements of this standard were originally published by the National Electrical Contractors Association in 1928 as part of the "Electragist Standards for Wiring Installations." They have been frequently quoted and included in handbooks on electrical installations. In some specifics they are more restrictive than the requirements of the National Electrical Code.)

8. Raceways (continued)

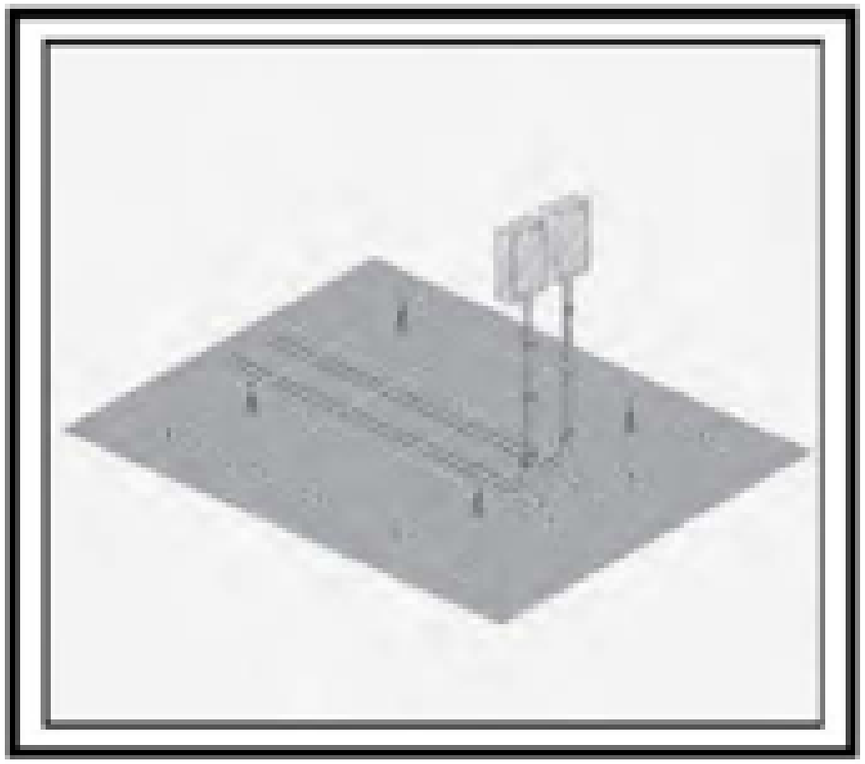
c) Care shall be taken to prevent the entrance of foreign matter into raceways and they shall be cleaned if necessary before pulling the conductors.

d) Stub-ups shall be protected from damage and carefully re-bent where necessary. Bends and offsets shall be carefully made so that the inside diameter is not effectively reduced. Unless otherwise required, the legs of a bend shall be in the same plane, and the straight legs of offsets shall be parallel.

8. Raceways (continued)

e) All raceway fittings shall be of a type compatible with the raceway and suitable for the use and location.

f) Unless otherwise specified, concealed raceways shall be run with the minimum of bends in the shortest practical distance considering the type of building construction and obstructions, as in the drawing.



8. Raceways (continued)

g) Raceways placed in concrete slab construction shall occupy the middle third when practical and leave at least 19 mm (3/4 inch) concrete cover. They shall be tied to the reinforcing rods or otherwise supported where necessary to prevent sagging when concrete is poured and shall be laterally spaced to allow concrete to pass between them.

h) Exposed raceways shall be run parallel and perpendicular to the building surface or exposed structural members and follow the surface contours as much as practical to present a neat appearance. Exception: Exterior raceways that are arranged to drain. Tables 2a and 2b (on the next two slides) list recommended minimum spacing between parallel raceways in order to provide sufficient room for terminations at boxes and cabinets.

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Table 2a: Minimum Raceway Spacing

Distance Between Centers in Inches at Junction and Pull Boxes
(Allows Approximately ¼-inch Spacing Between Locknuts)

Trade Size	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6
½	1⅝											
¾	1⅝	1⅞										
1	1⅝	1⅞	2⅛									
1¼	2	2⅛	2⅛	2⅜								
1½	2⅛	2⅛	2⅛	2⅜	2⅝							
2	2⅛	2⅛	2⅛	3	3⅛	3⅛						
2½	2⅝	2⅝	3	3⅛	3⅛	3⅝	3⅝					
3	3	3⅛	3⅛	3⅛	3⅝	4	4⅛	4⅛				
3½	3⅛	3⅛	3⅛	3⅜	4	4⅛	4⅛	4⅜	5⅛			
4	3⅛	3⅛	3⅜	4⅛	4⅛	4⅛	4⅛	5⅛	5⅛	5⅛		
5	4⅛	4⅛	4⅛	4⅛	4⅛	5⅛	5⅛	5⅛	6	6⅛	7	
6	4⅛	5	5⅛	5⅛	5⅛	5⅛	6	6⅛	6⅛	6⅛	7⅛	8⅛

Approximate Diameters

Trade Size	½	¾	1	1¼	1½	2	2½	3	3½	4	5	6
Conduit	⅞	1⅛	1⅜	1⅝	1⅞	2⅛	2⅜	3⅛	4	4⅜	5⅝	6⅝
Bushings	1	1⅛	1⅜	1¾	2⅛	2⅜	3⅛	3¾	4⅜	5	6⅛	7⅛
Locknuts	1⅛	1⅜	1⅝	2⅛	2⅛	3⅛	3⅛	4⅛	4⅝	5⅛	6⅝	7⅝

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Table 2b: Minimum Raceway Spacing

Distance Between Centers in Inches at Junction and Pull Boxes
(Allows Approximately 6 mm Spacing Between Locknuts)

Metric Designator	16	21	27	35	41	53	63	78	91	103	129	155
16	35											
21	38	45										
27	45	48	54									
35	50	54	60	66								
41	54	57	65	69	71							
53	60	66	69	75	78	90						
63	66	69	76	81	85	91	98					
78	75	78	81	90	95	100	103	115				
91	81	85	91	98	103	106	115	119	128			
103	90	91	98	103	106	115	119	128	135	141		
129	103	110	115	119	123	131	135	144	150	156	175	
155	119	125	128	135	140	148	150	160	166	171	191	210

Approximate Diameters

Metric Designator	16	21	27	35	41	53	63	78	91	103	129	155
Conduit	23	27	33	43	49	60	73	81	100	115	139	166
Bushings	25	32	38	48	53	66	80	98	111	125	156	185
Locknuts	28	36	46	58	66	80	90	106	121	135	168	199

8. Raceways (continued)

i) Exposed parallel or banked raceways shall be run together to provide a neat appearance. Bends in parallel or banked runs shall be made from the same center line so that the bends are parallel, as seen in the photo. Standard manufacturers' bends are allowed for groups of 90 degree bends if the conduits are close to the same sizes. This shall require that there be a change in the plane of the run, such as from wall to ceiling, and the raceways of the same size. In other cases, parallel raceways shall be field-bent.

8. Raceways (continued)

j) Raceways shall be joined with fittings designed for the purpose and shall be made tight. Where the installation situation is such that joints cannot be made tight, bonding jumpers shall be used to provide electrical continuity of the raceway system.

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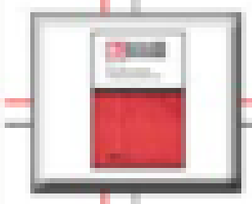
8. Raceways (continued)

k) Raceway terminations shall be made up tight. Where terminations are subject to vibration, bonding bushings or wedges shall be used to assure electrical continuity. Where subject to vibration or dampness, insulating bushings shall be used to protect the conductors. See pictures for examples.

8. Raceways (continued)

l) The set-screws of threadless fittings shall be made up tight with a suitable tool.

m) When raceways are terminated with locknuts and bushings, the raceway shall enter squarely and the locknuts shall be installed so that the convex (hollow) side is against the box. Two locknuts, one inside and the other outside the box, can also be used to facilitate the termination or to make it more secure.



8. Raceways (continued)

n) When terminating in threaded hubs, the raceway shall be screwed tightly into the hub. The shoulder of a fitting shall rest securely against the hub.

o) When chase nipples are used, the raceway and coupling shall be square to the box and the chase nipple tightened with no exposed threads.

p) Use conduit expansion fittings, flexible raceways, or cable wiring methods across all building expansion joints.

9. Wire and Cable

a) All wire and cable shall be suitable for the temperature, conditions, and location where installed.

b) Accessory materials, such as connectors, splice and tap fittings, and terminations shall be of a type designed or intended and suitable for the use. They shall be compatible with the conductor material.

c) Wire and cables shall be installed so as not to damage the insulation or cable sheath.

9. Wire and Cable (continued)

d) All conductors to be installed in a raceway shall be pulled together. They should be trained and guided into the raceway using an approved pulling compound or lubricant where necessary.

e) Existing conduits shall be cleaned prior to installing new conductors to ensure the outer jacket of the conductor is not damaged.

9. Wire and Cable (continued)

f) A means of communication, such as radio or intercom, shall be used between the pulling and guiding points to facilitate installation and to help prevent damage, as show in the drawing.

g) The pulling means (fish tape, cable or rope) shall be of a type that will not damage the raceway.

9. Wire and Cable (continued)

h) Cables that are installed exposed shall be run parallel and perpendicular to the surface of the building or exposed structural members and follow the surface contours as much as practical.

i) Running boards shall be used where necessary to provide sufficient support and a neat installation. Care shall be taken to provide sufficient mechanical protection for exposed cables.

j) All wires and cables, whether exposed, concealed or in raceways, shall be sufficiently supported using devices intended for the purpose.

9. Wire and Cable (continued)

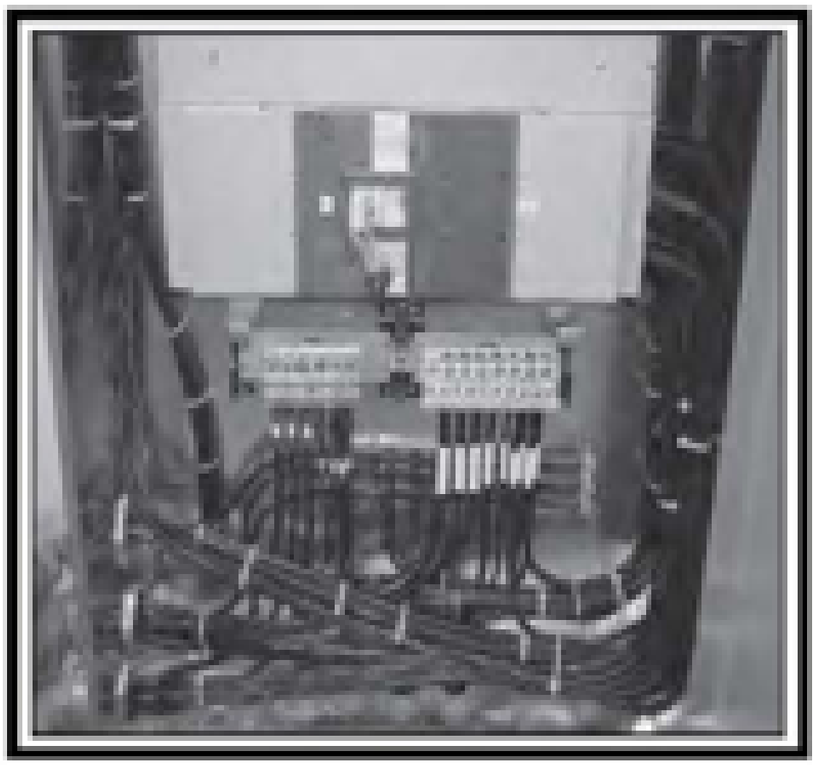
k) Conductors in raceways or cables shall not be supported by their terminations. *NOTE: This is to prevent the weight of the conductors or cables from damaging conductor insulation and to prevent the conductors from being pulled out of equipment terminals.*

l) Conductor splices shall be kept to a minimum.

m) Splices and taps shall have at least the equivalent mechanical strength and insulation as the conductors. Splice and tap devices shall be of the proper size and type for the use and compatible with the conductor material.

9. Wire and Cable (continued)

n) The length of conductors within cabinets and cutout boxes shall be sufficient to neatly train the conductor to the termination point with no excess, as shown. Allow sufficient cable length for thermal contraction of conductors to prevent damage of insulation or dislodging connections.



9. Wire and Cable (continued)

o) Terminations of insulated conductors shall be made so that the stripped length of bare conductor is not longer than required for the equipment terminal, lug, or connector. The conductor insulation shall bear against the terminal or connector shoulder, but not extend into the terminator point.

p) All conductors shall be identified in panelboards or other enclosures with a means that is neat, legible and permanent, such as by use of tags, pressure sensitive tape, or cable ties. All circuits shall be identified by a clearly lettered or typed directory in panelboards.

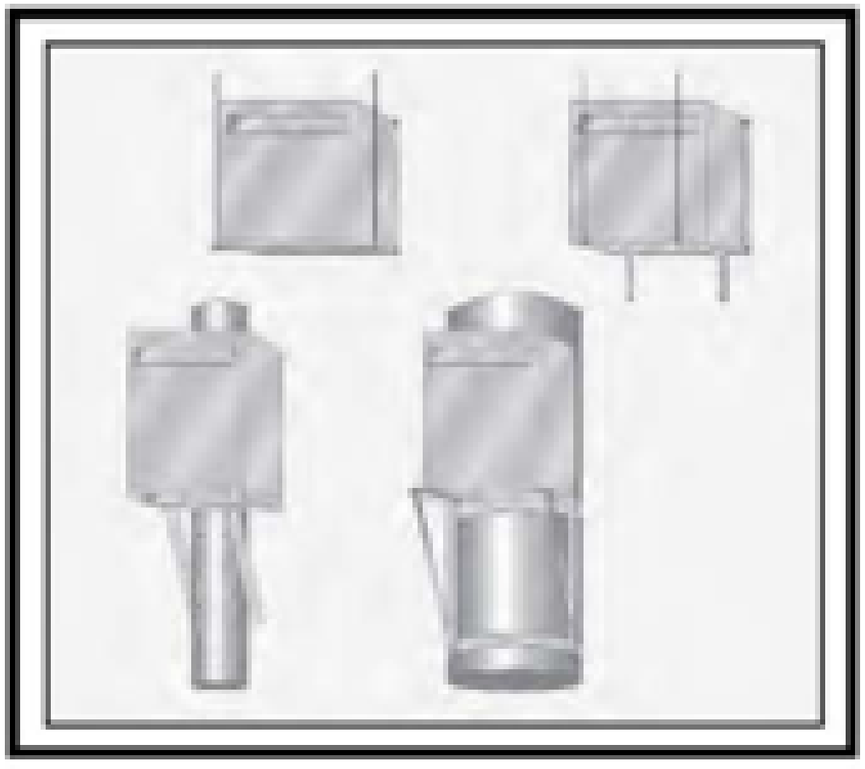
9. Wire and Cable (continued)

q) When using cable ties, do not over tighten, to ensure the cable tie does not cut the conductor's outer jacket. Cable ties shall not be used to support raceways or cables.

r) Use cable wiring methods, conduit expansion fittings, or flexible raceways across all building expansion joints.

10. Equipment Mounting

Equipment may be ceiling hung, wall mounted or floor mounted as appropriate, as shown. The general requirements for mounting and cooling of equipiment are provided in Section 110.13 of the *NEC*.



a) The fasteners or supports shall be sufficient to substantially secure the equipment in place to the building structure or structural element.

10. Equipment Mounting (continued)

b) In addition to the weight of the equipment, consideration shall be given to the type of load. For example, transformers and motors shall be considered vibration loads. Special consideration shall be given to manufacturer's recommendations.

c) Safety switches shall be considered shock loads. The supports may be standard manufactured items or job fabricated, and shall be appropriate for the location and compatible with the equipment.

10. Equipment Mounting (continued)

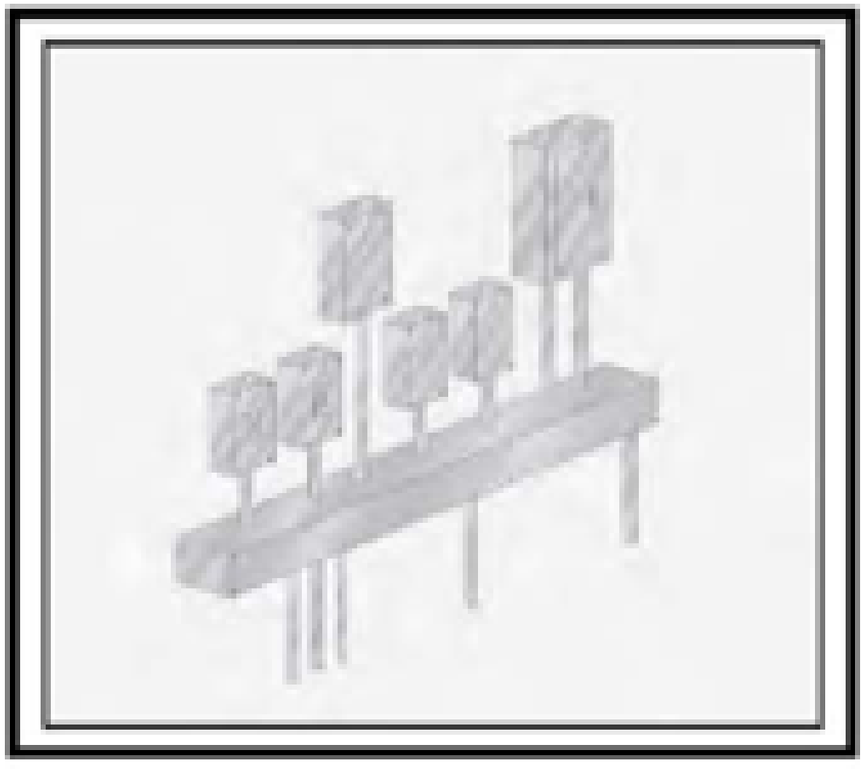
d) Equipment fasteners and supports shall have corrosion protection suitable for the atmosphere.

e) Selection of the fasteners and supports shall be based upon the strength of the materials and recognized safety factors.

10. Equipment Mounting (continued)

f) Equipment shall be installed plumb, true as intended and secure. All of these factors shall be immediately apparent.

g) When several items of equipment are wall mounted in the same area, care shall be taken to line them up vertically and horizontally, as shown.



10. Equipment Mounting (continued)

h) Raceways to and from the equipment shall be vertical and horizontal, using appropriate fittings or auxiliary gutters where necessary and practical for appearance.

i) Raceways or cable installed to floor mounted equipment from ceiling or overhead systems shall be additionally supported. Vibration isolation shall be used where needed.

10. Equipment Mounting (continued)

j) Where the equipment is mounted on a non-vibration foundation and the raceway is in the floor, the raceway shall be stubbed up within the foundation. The stub up shall be located as close as practical to the equipment termination point. *NOTE: NEC Section 408.5 requires that conduits or raceways, including their end fittings, shall not rise more than 75 mm (3 in.) above the bottom of an enclosure.*

10. Equipment Mounting (continued)

k) Raceway(s) to equipment subject to vibration shall be terminated in a box and final connections made with flexible conduit. The box shall be located as close as practical to the equipment terminals.

11. Mounting Heights

The mounting heights and location of wall switches, receptacles, clocks, fire alarm pull stations, and other devices and equipment are a matter of design. Those that are included in this standard shall be used when this information is not otherwise specified.

Consideration must be given to the practical installation situation, neatness and good workmanship. For example, fire bridging, furring strips or the like may not permit the installation of receptacles or wall switches at the heights listed here. Wainscotting may also cause variation. It is not considered good workmanship to have a finish plate span different types of building finishes.

11. Mounting Heights (continued)

a) Safety and convenience of users shall be of prime consideration in the location and mounting height of devices and equipment. Additional requirements in the Americans with Disabilities Act Guidelines (ADAG) shall be observed.

b) Intercom stations or devices that require hand operations, such as switches or fire alarm pull stations, shall be easily within reach by the average person without having to stretch or stoop or to use ladders or stools.

11. Mounting Heights (continued)

c) Switches shall be a maximum of 1.2 meters (48 inches) above finished floor, and fire alarm annunciation units shall be no lower than 2.0 meters (80 inches) above finished floor for ADAG compliance.

d) Convenience as well as appearance and good workmanship calls for consistency in the mounting height and location of similar devices and equipment.

e) Special-use or special-purpose outlets shall be located conveniently for the purpose intended.

11. Mounting Heights (continued)

11.1 Recommended Outlet Mounting Heights

Table 3, on the following slide, describes typical mounting heights for various outlets and control devices. All heights are measured from finished floor to centerline of device. These heights comply with the requirements of the ADAG (American with Disability Act Guidelines).

Standard for Good Workmanship in Electrical Construction

Table 3: Typical Mounting Heights

Wall switches	1.2 m (48 in.)
Receptacle outlets (general)	450 mm (18 in.)
Receptacle outlets (kitchen, utility room, workbenches, etc.)	1.0 m (42 in.) or 150 mm (6 in.) above countertop
Special purpose outlet	Within 1.8 mm (72 in.) of intended use
Telephone outlets	450 mm (18 in.)
Wall intercom stations	1.2 m (48 in.)
Night lights	450 mm (18 in.)
Wall lighting outlets	2.1 m (84 in.)
Thermostats	1.2 m (48 in.)
Push buttons	1.2 m (48 in.)
Elevator and hoistway control buttons	1.0 m (42 in.)
Bed lights	1.8 m (72 in.)
Patient bedside stations	1.2 m (48 in.)
Clock outlet	2.3 m (96 in.) when possible, or 150 mm (6 in.) below ceiling. *Above doors, center the clock outlet between door trim and ceiling*
Bells, Buzzers, chimes	2.3 m (96 in.) when possible, or 150 mm (6 in.) below ceiling
Fire alarm pull stations	1.2 m (48 in.)
Fire alarms (gongs, bells, horns, lights)	2.0 m (80 in.) above floor finish line, or 150 mm (6 in.) below ceiling

11. Mounting Heights (continued)

11.2 Heights of Disconnect Switches, Protective Devices, Controllers, etc.

The mounting height of disconnect switches, circuit breakers, motor controllers, push button stations, and other similar devices and equipment will vary depending upon location. The *National Electrical Code* requires that operating levers, handles, or buttons shall not be mounted more than 2.0 meters (6 feet, 7 inches) above the finish floor line (to the center of the operator in its highest position). Individual devices or pieces of equipment, unless otherwise specified, shall be located so that the operating handle, lever or button is located approximately 1.5 meters (60 inches) above the finish floor line.

11. Mounting Heights (continued)

11.3 Panelboards

Commercial. Panelboards in commercial and industrial occupancies shall be located so that thehighest overcurrent protective device is a maximum of 2.0 meters (6 feet, 7 inches) to the center of the grip of the operating handle above the finish floor line.

Residential. For ADAG compliance, panelboards in dwelling occupancies shall be located so that the highest overcurrent protective device is a maximum of 1.2 meters (48 inches) above the finish floor line.

(This annex is not part of the standard)

Annex A: Reference Standards

This publication, when used in conjunction with the *National Electrical Code* and manufacturers' literature, provides sufficient information to perform good workmanship in electrical construction. The following publications may also provide useful information:

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(617) 770-3000 or (617) 770-3500 fax
www.nfpa.org

Annex A: Reference Standards (continued)

This publication, when used in conjunction with the *National Electrical Code* and manufacturers' literature, provides sufficient information to perform good workmanship in electrical construction. The following publications may also provide useful information:

NFPA 70-2011, National Electrical Code (ANSI)

U.S. Access Board
(U.S. Architectural and Transportation Barriers Compliance Board)
1331 F Street, NW, Suite 1000
Washington, DC 20004-1111
(202) 272-5434 or (800) 872-2253 or (202) 272-5447 Fax
www.access-board.gov

Annex A: Reference Standards (continued)

This publication, when used in conjunction with the *National Electrical Code* and manufacturers' literature, provides sufficient information to perform good workmanship in electrical construction. The following publications may also provide useful information:

S14, Americans with Disability Act Guidelines (ADAG) (9/02)
National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 657-3110 tel
(301) 215-4500 fax
www.necanet.org

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards*™ published by NECA:

- NECA 1-2006, *Standard for Good Workmanship in Electrical Construction* (ANSI)
- NECA 90-2009, *Recommended Practice for Commissioning Building Electrical Systems* (ANSI)
- NECA 100-2006, *Symbols for Electrical Construction Drawings* (ANSI)
- NECA 101-2006, *Standard for Installing Steel Conduits* (Rigid, IMC, EMT) (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 102-2004, *Standard for Installing Aluminum Rigid Metal Conduit* (ANSI)
- NECA/AA 104-2006, *Recommended Practice for Installing Aluminum Building Wire and Cable* (ANSI)
- NECA/NEMA 105-2007, *Recommended Practice for Installing Metal Cable Tray Systems* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 111-2003, *Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC)* (ANSI)
- NECA/NACMA 120-2006, *Standard for Installing Armored Cable (AC) and Metal-Clad Cable (MC)* (ANSI)
- NECA 130-2010, *Standard for Installing and Maintaining Wiring Devices* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 169-2010, *Standard for Installing and Maintaining Arc-Fault Circuit Interrupters (AFCIs) and Ground-Fault Circuit Interrupters (GFCIs)* (ANSI)
- NECA 200-2010, *Recommended Practice for Installing and Maintaining Temporary Electric Power at Construction Sites* (ANSI)
- NECA 202-2006, *Standard for Installing and Maintaining Industrial Heat Tracing Systems* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 230-2010, *Standard for Selecting, Installing, and Maintaining Electric Motors and Motor Controllers* (ANSI)
- NECA/FOA 301-2009, *Standard for Installing and Testing Fiber Optic Cables* (ANSI)
- NECA 303-2005, *Standard for Installing Closed-Circuit Television (CCTV) Systems* (ANSI)
- NECA 305-2001, *Standard for Fire Alarm System Job Practices* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 331-2009, *Standard for Building and Service Entrance Grounding and Bonding*
- NECA 400-2007, *Standard for Installing and Maintaining Switchboards* (ANSI)
- NECA 402-2007, *Recommended Practice for Installing and Maintaining Motor Control Centers* (ANSI)
- NECA/EGSA 404-2007, *Standard for Installing Generator Sets* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 406-2003, *Standard for Installing Residential Generator Sets* (ANSI)
- NECA 407-2009, *Standard for Installing and Maintaining Panelboards* (ANSI)
- NECA 408-2009, *Standard for Installing and Maintaining Busways* (ANSI)
- NECA 409-2009, *Standard for Installing and Maintaining Dry-Type Transformers* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 410-2005, *Standard for Installing and Maintaining Liquid-Filled Transformers* (ANSI)
- NECA 411-2006, *Standard for Installing and Maintaining Uninterruptible Power Supplies (UPS)* (ANSI)
- NECA 420-2007, *Standard for Fuse Applications* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA 430-2006, *Standard for Installing Medium-Voltage Metal-Clad Switchgear* (ANSI)
- NECA/IESNA 500-2006, *Standard for Installing Indoor Commercial Lighting Systems* (ANSI)
- NECA/IESNA 501-2006, *Standard for Installing Exterior Lighting Systems* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA/IESNA 502-2006, *Standard for Installing Industrial Lighting Systems* (ANSI)
- NECA 503-2005, *Standard for Installing Fiber Optic Lighting Systems*
- NECA/BICSI 568-2006, *Standard for Installing Commercial Building Telecommunications Cabling* (ANSI)

Annex A: Reference Standards (continued)

Current *National Electrical Installation Standards™*: (continued)

- NECA/MACSCB 600-2003, *Recommended Practice for Installing and Maintaining Medium-Voltage Cable* (ANSI)
- NECA/NEMA 605-2005, *Recommended Practice for Installing Underground Nonmetallic Utility Duct* (ANSI)
- NECA 700-2010, *Standard for Installing Overcurrent Protection to Achieve Selective Coordination* (ANSI)

Standard for Good Workmanship in Electrical Construction

National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, Maryland 20785
301-657-3110 • 301-214-4500 fax
www.necanet.org

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End of
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