NEMA Standards Publication ICS 6-1993 (R 2001)

Industrial Control and Systems: Enclosures

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Foreword

This standards publication was prepared by a technical committee of the NEMA Industrial Automation Control Products and Systems Section. It was approved in accordance with the bylaws of NEMA and supersedes the indicated NEMA Standards Publication. This standards publication supersedes ICS 6-1993.

This standards publication provides practical information concerning ratings, construction, test, performance and manufacture of industrial control equipment. These standards are used by the electrical industry to provide guidelines for the manufacture and proper application of reliable products and equipment and to promote the benefits of repetitive manufacturing and widespread product availability.

NEMA standards represent the result of many years of research, investigation, and experience by the members of NEMA, its predecessors, its sections and committees. They have been developed through continuing consultation among manufacturers, users and national engineering societies and have resulted in improved serviceability of electrical products with economies to manufacturers and users.

One of the primary purposes of this standards publication is to encourage the production of reliable control equipment which, in itself, functions in accordance with these accepted standards. Some portions of these standards, such as electrical spacings and interrupting ratings, have a direct bearing on safety; almost all of the items in this publication, when applied properly, contribute to safety in one way or another.

Properly constructed industrial control equipment is, however, only one factor in minimizing the hazards, which may be associated with the use of electricity. The reduction of hazard involves the joint efforts of the various equipment manufacturers, the system designer, the installer and the user. Information is provided herein to assist users and others in the proper selection of control equipment.

The industrial control manufacturer has limited or no control over the following factors, which are vital to a safe installation:

a) Environmental conditions
b) System design
c) Equipment selection and application
d) Installation
e) Operating practices
f) Maintenance

This publication is not intended to instruct the user of control equipment with regard to these factors except insofar as suitable equipment to meet needs can be recognized in this publication and some application guidance is given.

This standards publication is necessarily confined to defining the construction requirements for industrial control equipment and to providing recommendations for proper selection for use under normal or certain specific conditions. Since any piece of industrial control equipment can be installed, operated and maintained in such a manner that hazardous conditions may result, conformance with this publication does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected

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and is installed in accordance with the National Electrical Code and properly maintained, the hazards to persons and property will be reduced.

To continue to serve the best interests of users of Industrial Control and Systems equipment, the Industrial Automation Control Products and Systems Section is actively cooperating with other standardization organizations in the development of simple and more universal metrology practices. In this publication, the U.S. customary units are gradually being supplemented by those of the modernized metric system known as the International Systems of Units (SI). This transition involves no changes in standard dimensions, tolerances, or performance specifications.

NEMA standards publications are subject to periodic review. They are revised frequently to reflect user input and to meet changing conditions and technical progress.

Proposed revisions to this standards publication should be submitted to:

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Rosslyn, Virginia 22209

This standards publication was developed by the Industrial Automation Control Products and Systems Section. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the Industrial Automation Control Products and Systems Section consisted of the following members:

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Section 1
GENERAL

1.1 REFERENCED STANDARDS

The following standards contain provisions which, through reference in this text, constitute provision of this NEMA Standard Publication. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

American Society of Mechanical Engineers
345 East 47th Street
New York, NY 10017

ASME B1.20.1-1983 (R1992) *Pipe Threads (General Purpose)*

Canadian Standards Association
178 Rexdale Blvd.
Rexdale, Ontario M9W 1R3 Canada

CSA C22.2-0-M91 (R1997) *General Requirements - Canadian Electrical Code, Part II*

CSA C22.2-0.5-1982 (R1999) *Threaded Conduit Entries*

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1300 North 17th Street, Suite 1847
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FB 1-1993 *Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies*

ICS 1-2000 *Industrial Control and Systems General Requirements*

ICS 1.3-1986 (R2001) *Preventive Maintenance of Industrial Control and Systems Equipment*

NEMA 250-1997 *Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

ANSI/NFPA 70-1999 *National Electrical Code*

Underwriters Laboratories, Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 508-1999 *Industrial Control Equipment (17th Ed)*

UL 698-1995 *Industrial Control Equipment for Use in Hazardous Locations*

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1.2 SCOPE

The standards in this publication apply to enclosures used for all enclosed products within the scope of the Industrial Automation Control Products and Systems Section.

1.3 NORMATIVE STANDARDS

The definitions and standards of NEMA Standards Publications No. 250 and ICS 1 apply, except that the 1,000-volt maximum limitation does not apply to enclosures for industrial control and systems.

1.4 GENERAL REQUIREMENTS

Enclosure types for products within the scope of the Industrial Automation Control Products and Systems Section shall meet all the requirements of NEMA Standards Publication No. 250 and also the requirements contained herein except that the enclosure with its enclosed equipment for hazardous locations need only meet the requirements of UL 698.

2 DEFINITIONS

See NEMA Standards Publication No. 250 for definitions applying to this standard.

3 CLASSIFICATION

3.1 STANDARD ENCLOSURE TYPES

Enclosure types for products within the scope of the Industrial Controls and Systems Section shall be Types 1, 2, 3, 3R, 3S, 4, 4X, 5, 6, 6P, 7, 8, 9, 10, 12, 12K and 13 as defined by NEMA Standards Publication No. 250.

3.2 MULTIPLE TYPE DESIGNATIONS

Enclosures shall be designated by the type number indicating the external conditions for which they are suitable. A single enclosure which meets the requirements for more than one type of enclosure shall be permitted to be designated by a series of type numbers, the lesser number being given first.

4 CHARACTERISTICS AND RATINGS

This publication contains no ratings.

5 PRODUCT MARKING, INSTALLATION, AND MAINTENANCE INFORMATION

5.1 MARKING

Enclosures shall be marked with their type designation(s).

5.2 ENCLOSURE GROUNDING

Conductive material which encloses electric conductors or equipment or forms part of such equipment must be grounded.

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Metal enclosures in fixed installations are normally grounded by connection via armored cable, metal conduit, or metal raceway.

5.3 TAPERED PIPE THREADS

Tapered pipe threads provided for installation of rigid conduit are intended to be made up wrench-tight with a sealant to prevent spiral leakage through the gaps at the crests and roots of the mating threads.

5.4 MAINTENANCE

See ICS 1.3 for general maintenance instructions.

6 SERVICE AND STORAGE CONDITIONS

The external environmental limits for the enclosure are established by the enclosure design test procedures of NEMA Standards Publication No. 250.

See ICS 1, Part 6, for storage conditions.

7 CONSTRUCTION

This part constitutes the Industrial Automation Control Products and Systems Section manufacturing standards for enclosures as referenced in NEMA Standards Publication No. 250.

7.1 STRENGTH OF ENCLOSURES

7.1.1 Sheet Metal Enclosures

The minimum thickness required for sheet metal enclosures varies with the size of the enclosure. Based on the use of solid sheet metal without any openings other than those required for operating handles or shafts or for ventilation, the thickness shall be not less than that given in Table 7-1 and Table 7-2 and, at points where conduit or armored cable is connected, not less than 0.032 inch (0.81 mm) where made of steel and not less than 0.045 inch (1.14 mm) where made of nonferrous metal. For large enclosures, such as those used for complex multicomponent controllers, where the enclosure surface does not contribute to the structural integrity of the enclosure and deformation would not increase electrical hazards, Table 7-1 and Table 7-2 do not apply.

7.1.2 Cast Metal Enclosures

Cast metal, other than die-cast metal, shall be at least 1/8 inch (3.2 mm) thick at every point and of greater thickness at reinforcing ribs and door edges and shall be at least 1/4 inch (6.4 mm) thick at threaded holes for conduit. Die-cast metal shall be not less than 3/32 inch (2.4 mm) thick for an area which is greater than 24 square inches (155 cm^2) or in which any dimension is greater than 6 inches (152 mm), and shall be not less than 1/16 inch (1.6 mm) thick for an area which is 24 square inches (155 cm^2) or less in which no dimension is greater than 6 inches (152 mm), and shall be at least 1/4 inch (6.4 mm) thick at threaded holes for conduit.

7.1.3 Securing Means

Removable or hinged parts of enclosures such as doors, covers, etc., shall be provided with means for firmly securing them in place.

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Table 7–1
THICKNESS OF CARBON OR STAINLESS–STEEL SHEET METAL ENCLOSURES
MAXIMUM DIMENSIONS OF ANY SURFACE, INCHES

Without Supporting Frame*		With Supporting Frame or Equivalent Reinforcing*		Minimum Thickness	
Maximum Width**	Maximum Length†	Maximum Width**	Maximum Length	Uncoated	Zinc Coated
4.0	Not limited	6.25	Not limited	0.020‡	0.023‡
4.75	5.75	6.75	8.25	0.020‡	0.023‡
6.0	Not limited	9.5	Not limited	0.026‡	0.029‡
7.0	8.75	10.0	12.5	0.026‡	0.029‡
8.0	Not limited	12.0	Not limited	0.032	0.034
9.0	11.5	13.0	16.0	0.032	0.034
12.5	Not limited	19.5	Not limited	0.042	0.045
14.0	18.0	21.0	25.0	0.042	0.045
18.0	Not limited	27.0	Not limited	0.053	0.056
20.0	25.0	29.0	36.0	0.053	0.056
22.0	Not limited	33.0	Not limited	0.060	0.063
25.0	31.0	35.0	43.0	0.060	0.063
25.0	Not limited	39.0	Not limited	0.067	0.070
29.0	36.0	41.0	51.0	0.067	0.070
33.0	Not limited	51.0	Not limited	0.080	0.084
38.0	47.0	54.0	66.0	0.080	0.084
42.0	Not limited	64.0	Not limited	0.093	0.097
47.0	59.0	68.0	84.0	0.093	0.097
52.0	Not limited	80.0	Not limited	0.108	0.111
60.0	74.0	84.0	103.0	0.108	0.111
63.0	Not limited	97.0	Not limited	0.123	0.126
73.0	90.0	103.0	127.0	0.123	0.126

*A supporting frame structure is an angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected. Construction which is considered to have equivalent reinforcing may be accomplished by a multiplicity of designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Constructions considered to be "without supporting frame" include:

a. A single sheet with single formed flanges (formed edges)
b. A single sheet which is corrugated
c. An enclosure surface loosely attached to a frame as, for example, with spring clips

** The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure and supported at all four edges; where a surface is supported at fewer than four edges, the width is to be considered the maximum dimension between supporting edges. Supported at the edge means fastened to or otherwise having a relatively solid support, stiffened member, or reinforcing by forming so as to prevent or minimize the deflection of the sheet metal. Adjacent surfaces shall be permitted to have supports in common and be made of a single sheet.

†"Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

‡Sheet steel for an enclosure intended for outdoor use shall be not less than 0.034 inch (0.86 mm) thick if zinc coated and not less than 0.032 inch (0.81 mm) thick if uncoated.

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Table 7-2
THICKNESS OF ALUMINUM, COPPER, OR BRASS SHEET METAL ENCLOSURES
MAXIMUM DIMENSIONS OF ANY SURFACE, INCHES

Without Supporting Frame*		With Supporting Frame or Equivalent Reinforcing*		
Maximum Width**	Maximum Length†	Maximum Width**	Maximum Length	Minimum Thickness
3.0	Not limited	7.0	Not limited	0.023‡
3.5	4.0	8.5	9.5	0.023‡
4.0	Not limited	10.0	Not limited	0.029
5.0	6.0	10.5	13.5	0.029
6.0	Not limited	14.0	Not limited	0.036
6.5	8.0	15.0	18.0	0.036
8.0	Not limited	19.0	Not limited	0.045
9.5	11.5	21.0	25.0	0.045
12.0	Not limited	28.0	Not limited	0.058
14.0	16.0	30.0	37.0	0.058
18.0	Not limited	42.0	Not limited	0.075
20.0	25.0	45.0	55.0	0.075
25.0	Not limited	60.0	Not limited	0.095
29.0	36.0	64.0	78.0	0.095
37.0	Not limited	87.0	Not limited	0.122
42.0	53.0	93.0	114.0	0.122
52.0	Not limited	23.0	Not limited	0.153
60.0	74.0	130.0	160.0	0.153

*A supporting frame structure is an angle or channel or a folded rigid section of sheet metal which is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and which has sufficient torsional rigidity to resist the bending moments applied via the enclosure surface when it is deflected. Construction which is considered to have equivalent reinforcing may be accomplished by a multiplicity of designs that will produce a structure which is as rigid as one built with a frame of angles or channels. Constructions considered to be "without supporting frame" include:

a. A single sheet with single formed flanges (formed edges)
b. A single sheet which is corrugated
c. An enclosure surface loosely attached to a frame as, for example, with spring clips

**The width is the smaller dimension of a rectangular sheet metal piece which is part of an enclosure and supported at all four edges; where a surface is supported at fewer than four edges, the width is to be considered the maximum dimension between supporting edges. Supported at the edge means fastened to or otherwise having a relatively solid support, stiffened member, or reinforcing by forming so as to prevent or minimize the deflection of the sheet metal. Adjacent surfaces shall be permitted to have supports in common and be made of a single sheet.

†"Not limited" applies only if the edge of the surface is flanged at least 1/2 inch (12.7 mm) or fastened to adjacent surfaces not normally removed in use.

‡Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall be not less than 0.029 inch (0.74 mm) thick.

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7.2 VENTILATING OPENINGS

7.2.1 General

Ventilating openings shall be designed to prevent entry of a rod having the diameter specified in NEMA Standards Publication No. 250 for the type of ventilated enclosure.

7.2.2 Perforated or Expanded Sheet Metal

Except as noted in the following paragraph, the thickness of sheet metal employed in expanded metal mesh and perforated sheet metal shall be not less than 0.042 inch (1.07 mm) where made of steel and 0.058 inch (1.47 mm) where made of nonferrous material. Where the mesh openings or perforations are greater than 1/2 square inch (323 mm^2) in area, the thickness of the metal shall be not less than 0.080 inch (2.03 mm) where made of steel and 0.112 inch (2.84 mm) where made of nonferrous material.

An expanded metal mesh of not less than 0.020 inch (0.51 mm) steel or not less than 0.029 inch (0.74 mm) non-ferrous material shall be permitted to cover an opening where an indentation will not affect the operation of a movable part or the clearance between uninsulated current-carrying parts and grounded metal provided that either:

a. The total area of the exposed mesh on any one side of the enclosure is not greater than 72 square inches (464 cm^2) and has no dimension which is greater than 12 inches (305 mm).
b. The width of an opening so protected is not greater than 3-1/2 inches (89 mm).

7.2.3 Screen Enclosures

All enclosures which are composed of wire mesh, perforated screens, or grill work shall be provided with a supporting frame.

7.2.4 Minimum Screen Wire Size

Where openings are screened, the wire gauge of the screen shall be not less than No. 16 AWG. Where the screen mesh openings are greater than 1/2 square inch (323 mm^2) in area, the wire gauge shall be not less than No. 12 AWG.

7.2.4.1.1 Type 5 and Type 12 Ventilated Enclosures

Enclosure Types 5 and 12 may include sections or compartments that are ventilated. These sections or compartments need not meet the dust test requirements but should meet the test requirements for Type 1 and Type 2 enclosures. In such a case either a separate designation for each type compartment should be placed on each compartment or a single nameplate may state: Type 12 with Type 1 compartment.

7.3 WIRE ENTRANCES

7.3.1 Knockouts

Table 7-3 lists the ranges of conduit sizes for which knockouts are to be provided in enclosures for AC controllers Size 5 or smaller. The table is based on using one conduit entrance for line wires and one conduit entrance for load wires.

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Table 7–3
RANGES OF WIRE AND KNOCKOUT SIZES

Controller Size	Range of Wire Sizes Required for Line and Load*, AWG or kcMil		Knockouts for three Line or three Load Wires**	
			Range of Sizes of Conduit for Copper Wire Alone	Ranges of Sizes of Conduit for Aluminum and Copper Wire
	Copper	Aluminum		
00	14	12	½	½
0	14-10	12-8	½	½, ¾
1	14-8	12-6	½, ¾	½, ¾, 1
1P	8-6	8-4	½, ¾	½, ¾, 1
2	10-4	10-3	½, ¾, 1	½, ¾, 1, 1-¼
3	8-1/0	8-3/0	¾, 1, 1-¼, 1-½	¾, 1, 1-¼, 1-½, 2
4	4-3/0	2-250	1, 1-¼, 1-½, 2	1, 1-¼, 1-½, 2, 2-½
5	2/0-500	4/0-700	1-½, 2, 2-½, 3	1-½, 2, 2-½, 3, 3-½

*Derating factors for 60ºC and 75ºC wire in a 40ºC ambient are 0.82, and 0.88 respectively, with not more than three conductors in raceway. The maximum wire size shown is for a 40ºC ambient based on the ampacity required for service limit current or 125 percent of maximum motor full load current corresponding to horsepower whichever is greater. The minimum wire size shown is for 75ºC insulation in a 30ºC ambient and minimum motor full load current corresponding to horsepower.

**Largest knockout is based on use of 60ºC wire for controller sizes 00 through 3 and 75ºC wire for controller sizes 4 and 5.

7.3.2 Knockout Diameters and Conduit Bushing Dimensions

Table 7-4 shows the knockout diameters and conduit bushing dimensions to be taken into consideration when designing enclosures and mounting the enclosed apparatus (See Figure 7-1).

7.3.3 Threaded Conduit Hubs

Where provided, conduit entrances for type 3, 3R, 3S, 4, 4X, 6, 7, 8, 9, and 10 enclosures shall be in the top and in the bottom of the enclosure. Where provisions are made for threaded conduit connections in these enclosures for AC controllers Size 5 or smaller, there shall be one 3/4-inch conduit entrance in the bottom of magnetic controllers for control wires plus one conduit entrance in the top of manual and magnetic controllers for line conductors and one conduit entrance in the bottom of manual and magnetic controllers for load conductors in accordance with Table 7-5.

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Table 7–4
KNOCKOUT DIAMETERS AND CONDUIT BUSHING DIMENSIONS (See Figure 7-1)

Nominal Size of Conduit	Knockout Diameter,* Inches			Bushing		
				Minimum Diameter at Flange†	Minimum Over Knockout	Height,
				Inches	Inches	Inches
Inches	Nominal**	Minimum	Maximum	(Dimension A)		(Dimension H)
1	2	3	4	5	6	7
½	0.875	0.859	0.906	1.00	0.033	0.375
¾	1.109	1.094	1.141	1.23	0.021	0.422
1	1.375	1.359	1.406	1.54	0.040	0.516
1¼	1.734	1.719	1.766	1.92	0.045	0.562
1½	1.984	1.958	2.016	2.18	0.045	0.594
2	2.469	2.433	2.500	2.68	0.047	0.625
2½	2.969	2.938	3.000	3.20	0.053	0.750
3	3.594	3.563	3.625	3.83	0.056	0.812
3½	4.125	4.063	4.156	4.40	0.060	0.937
4	4.641	4.563	4.672	4.94	0.062	1.000
4½	5.109	5.063	5.166	5.51	0.130	1.062
5	5.719	5.625	5.750	6.05	0.071	1.187
6	6.813	6.700	6.844	7.20	0.081	1.250

*These diameters apply to single or concentric types only and exclude any projection of breakout ears or tabs.

**It is desirable the diameter of the knockout be held as close as possible to the nominal diameter given in Column 2.

†These diameters at the flange of the conduit bushing are minimum in order to obtain the overlap shown in Column 6 with maximum knockout diameter.

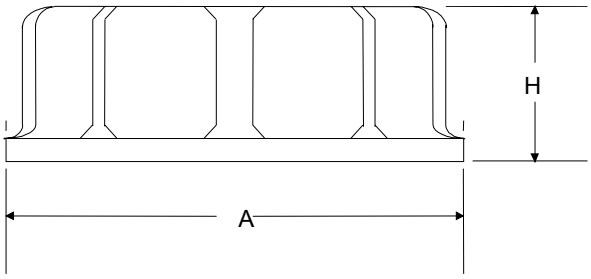


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Figure 7–1
BUSHING DIMENSIONS

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Table 7–5
CONDUIT SIZES FOR CONTROLLERS*

Size of Controller	Conduit Sizes for Line or Load Wires, Inches
00	¾
0	¾
1	1
1P	1
2	1½
3	2
4	2½
5	3½

*The values given are based on the use of wires whose insulation is rated either 60ºC or 75ºC.

7.3.4 Threaded Holes for Rigid Conduit

Tapered pipe threads for rigid steel electrical conduit and conduit connections are a special application of pipe threads where a longer engagement is desirable for grounding and strength considerations.

The pitch diameter of the external thread on the conduit remains the same as for standard pipe threads, but the pitch diameter at the entrance to the internal thread is made larger to provide for longer thread engagement.

Table 7-6 specifies the tapered internal thread engagement which should be provided for in enclosures designed with integral bushings to accept rigid conduit. The turns engagement method of gauging determines that an adequate number of threads are available. The plug gauge is screwed hand-tight into the enclosure. A threaded hole with integral bushings is acceptable if the hand-tight engagement of the gauge is within the limits given in Table 7-6 and there is a minimum of one full thread available beyond the end of the plug gauge. This clearance ensures that the smallest permissible external thread will tighten against the thread, and not bottom against the bushing. See Figure 7-2. Some recommended hole sizes for rigid conduit threads with integral bushings are shown in Table 7-7 (See Figure 7-3 and 7-4). The sizes shown permit tapping to meet the ANSI Standards requirements of Table 7-6.

When integral bushings are not provided in enclosures designed to accept rigid conduit, the enclosure wall thickness should be held to the values shown in Table 7-8 so that sufficient threads will protrude through the wall for attachment of a separate bushing, without requiring additional threading of the conduit. (See Figure 7-5.)

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Table 7–6
INTERNAL THREAD REQUIREMENTS FOR RIGID CONDUIT IN ENCLOSURES WITH INTEGRAL BUSHINGS

Nominal or Trade Size of Conduit		ANSI Publications					CSA Publications					
		Applicable to all ANSI		NEMA FB 1	UL 508	UL 698	CSA C22.2-0-M*		C22.2-0.5			
		Turns Penetration		Threads Engaged			Min. Threads Engaged				Min. Threads Engaged	
Inches	Threads per Inch	Min. **	Max.†	Minimum			Other Than Class 1 Loc.	Class 1 Haz. Loc.	Min. Turns Penetration	Max. Turns Penetration	Other than Class 1 Loc.	Class 1 Haz. Loc.
½	14	6	9	5	3½	5	3½	5	5	7	3½	5
¼	14	6	9	5	3½	5	3½	5	5¼	7¼	3½	5
1	11½	6	9	5	3½	5	3	5	5	7⅛	3	5
1¼	11½	6	10	5	3½	5	3	5	5 ⅜	7 ⅜	3	5
1½	11½	6	10	5	3½	5	3	5	5⅜	7⅜	3	5
2	11½	6	10	5	3½	5	3	5	5½	7½	3	5
2½	8	6	10	5	3½	5	3	5	6	8	3	5
3	8	6	10	5	3½	5	3	5	6⅝	8⅝	3	5
3½	8	7	11	5	3½	5	3	5	7⅛	9½	3	5
4	8	7	11	5	3½	5	3	5	7¼	9½	3	5
4½	8	7	11	5	3½	5	3	5	7½	9½	3	5
5	8	7	11	5	3½	5	3	5	8	10	3	5
6	8	7	11	5	3½	5	3	5	8⅛	10½	3	5

*CSA C22,2-0-M does not specify thread fit.

**As gauged with a working gauge complying with Section 7 of ANSI B1.20.1

†NEMA FB 1 requires five full threads engagement unless otherwise specified.

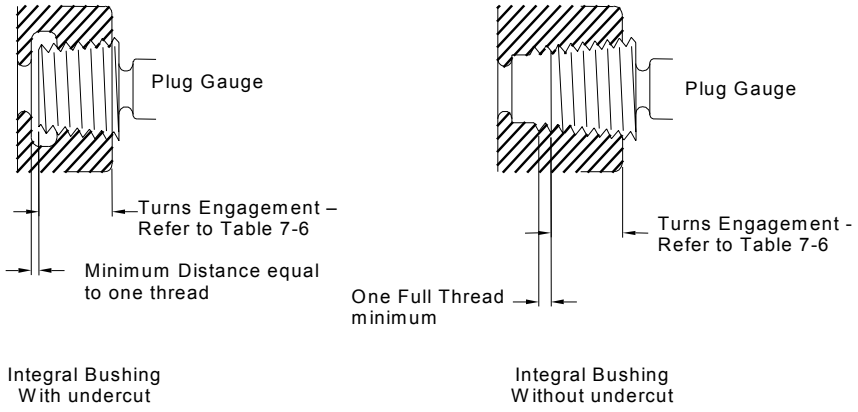


Figure 7–2
TURNS ENGAGEMENT METHOD OF GAUGING THREADED HOLES

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Table 7–7
RECOMMENDED DIMENSIONS, INCHES, FOR RIGID CONDUIT CONNECTIONS IN ENCLOSURES WITH INTEGRAL BUSHINGS

Nominal or Trade Size of Conduit	Threads per Inch	Without Undercut (Figure 7-3)		With Undercut (Figure 7-4)				Throat Diameter D3	
		Entrance Diameter D1	Depth L1	Entrance Diameter D1	Depth L1	Undercut Diameter D2	Undercut Depth L2	Minimum	Maximum
½	14	0.723	0.929	0.723	0.786	0.840	0.214	0.560	0.622
¾	14	0.932	0.929	0.932	0.786	1.050	0.214	0.742	0.824
1	11.5	1.170	1.130	1.170	0.957	1.315	0.261	0.944	1.047
1¼	11.5	1.514	1.217	1.514	1.044	1.660	0.261	1.242	1.380
1½	11.5	1.753	1.217	1.753	1.044	1.900	0.261	1.449	1.610
2	11.5	2.226	1.217	2.226	1.044	2.375	0.261	1.860	2.067
2½	8	2.658	1.750	2.658	1.500	2.875	0.375	2.222	2.467
3	8	3.279	1.750	3.279	1.500	3.500	0.375	2.761	3.066
3½	8	3.783	1.875	3.783	1.625	4.000	0.375	3.193	3.548
4	8	4.280	1.875	4.280	1.625	4.500	0.375	3.623	4.026
4½	8	4.810	1.875	4.810	1.625	5.032	0.375	4.084	4.537
5	8	5.337	1.875	5.337	1.625	5.563	0.375	4.542	5.045
6	8	6.392	1.875	6.392	1.625	6.625	0.375	5.458	6.065

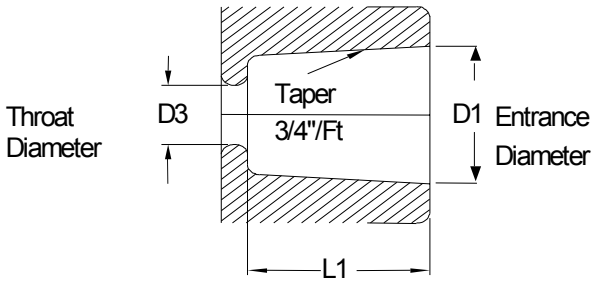


Figure 7–3
RIGID CONDUIT, INTEGRAL BUSHING WITHOUT UNDERCUT

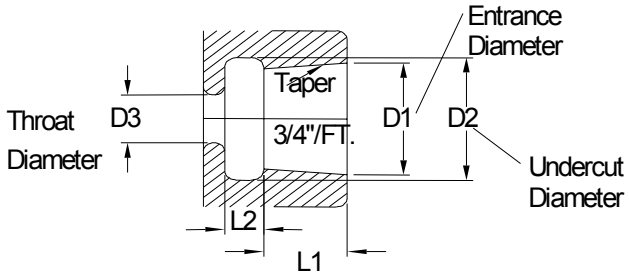


Figure 7–4
RIGID CONDUIT, INTEGRAL BUSHING WITH UNDERCUT

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Table 7–8
HOLE SIZES AND WALL THICKNESSES, INCHES, FOR RIGID CONDUIT CONNECTIONS USING BUSHINGS ATTACHED TO END OF CONDUIT

Nominal or Trade Size of Conduit	Threads per Inch	Entrance Diameter Cored or Reamed (Taper ¾in/ft)	Enclosure Wall Thickness	
			Minimum	Maximum
½	14	0.723	0.250	0.286
¾	14	0.932	0.250	0.286
1	11.5	1.170	0.305	0.348
1¼	11.5	1.514	0.305	0.348
1½	11.5	1.753	0.305	0.348
2	11.5	2.226	0.305	0.348
2½	8	2.658	0.438	0.500
3	8	3.279	0.438	0.500
3½	8	3.783	0.438	0.625
4	8	4.280	0.438	0.625
4½	8	4.810	0.438	0.625
5	8	5.337	0.438	0.625
6	8	6.392	0.438	0.625

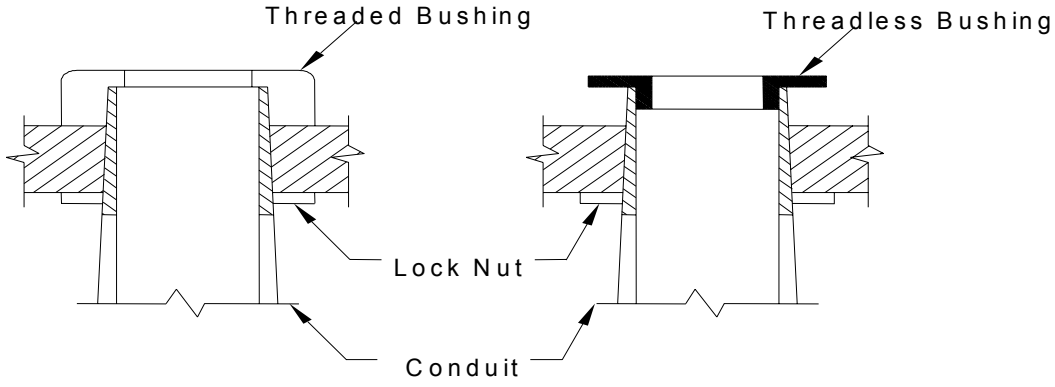


Figure 7–5
CONDUIT BUSHINGS

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7.4 ELECTRICAL SPACINGS

Spacings between any live part and the enclosure wall shall be as shown in ICS 1, Part 7, except that a greater spacing is required if the enclosure is not rigid. The spacings shall be permitted to be less than those shown in ICS 1, Part 7 if the enclosure is lined with an insulating material.

7.5 WIRE–BENDING SPACE

Enclosures shall be constructed so that, after the apparatus has been mounted within the enclosure, there will be adequate room for wiring (see Table 7-9, Table 7-10, and Table 7-11). This wiring space is the distance between the end of the lug, pressure wire connector, or terminal screw (whichever is least) and the point on the wall of the enclosure toward which the conductor will be initially directed. Where a conductor is restricted from bending, by means of barriers or otherwise, as it leaves the lug, the distance shall be measured from the end of the restriction.

7.6 PROVISIONS FOR GROUNDING

Nonmetallic enclosures and enclosures used as pendants require a terminal to bond the apparatus to a grounding conductor included in the cable or nonmetallic conduit. The fundamental requirement is a continuous low-impedance circuit between all metal conduit and all metallic parts which project through the enclosure.

Where a grounding conductor is furnished by the apparatus manufacturer, it should be green with or without a yellow stripe. Where a screw is furnished for the installer to use in making a grounding connection, a screw with a slotted hexagonal green-colored head is preferred.

7.7 LEGENDS

Legends and instruction information appearing on the exterior of the enclosure should be applied in such a manner as to have a degree of permanence and legibility commensurate with the environment and application for which the enclosure is intended.

8 PERFORMANCE REQUIREMENTS AND TESTS

8.1 GENERAL

See NEMA Standards Publication No. 250 for enclosure test requirements.

8.2 NONMETALLIC ENCLOSURES

Polymeric enclosures shall also be evaluated in accordance with UL 508.

8.3 TYPE 5 AND TYPE 12 ENCLOSURES WITH VENTILATED COMPARTMENT

See 7.2.5.

9 APPLICATION

See NEMA Standards Publication No. 250 for application information.

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Table 7–9
WIRE–BENDING SPACE FOR FIELD CONNECTIONS
(ENCLOSED MOTOR CONTROLLERS)

Maximum Wire Size, AWG or MCM	Minimum Bending Space, Inches	
	1 wire per pole	2 wires per pole*
14-10 AWG	Not	…
8-6	1½	…
4-3	2	…
2	2½	…
1	3	…
0	5	5
00	6	6
000-0000 MCM	7	7
250	8	8
300	10	10
350-500	12	12
600-700	14	16
750-900	18	19

*Where provision for three or more wires per terminal exists, the minimum wire-bending space shall be in accordance with the requirements of Article 373, National Electrical Code.

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Table 7–10
WIRE BENDING SPACE, INCHES (MILLIMETERS), FOR CONDUCTORS LEAVING THE ENCLOSURE THROUGH THE WALL OPPOSITE THE TERMINALS (MOTOR CONTROL CENTERS)

Wire Size	Minimum Bending Space*, Inches (mm)											
AWG or MCM	1 Wire per Terminal			2 Wires per Terminal			3 Wires per Terminal			4 or More Wires per Terminal		
14-10 AWG	Not Specified											
8	1½	(38.1)		…			…			…		
6	2	(50.8)		…			…			…		
4	3	(76.2)		…			…			…		
3	3	(76.2)		…			…			…		
2	3½	(88.9)		…			…			…		
1	4½	(114)		…			…			…		
0	5½	(140)		5½	(140)		7	(178)		…		
2/0	6	(152)		6	(152)		7½	(191)		…		
3/0	6½	(165)	[6]	6½	(165)	[6]	8	(203)		…		
4/0	7	(178)	[6]	7½	(191)	[6]	8½	(216)	[8]	…		
250 MCM	8½	(216)	[6½]	8½	(216)	[6½]	9	(229)	[8]	10	(254)	
300	10	(254)	[7]	10	(254)	[8]	11	(279)	[10]	12	(305)	
350	12	(305)	[9]	12	(305)	[9]	13	(330)	[10]	14	(356)	[12]
400	13	(330)	[10]	13	(330)	[10]	14	(356)	[11]	15	(381)	[12]
500	14	(356)	[11]	14	(356)	[11]	15	(381)	[12]	16	(406)	[13]
600	15	(381)	[12]	16	(406)	[13]	18	(457)	[15]	19	(483)	[16]
700	16	(406)	[13]	18	(457)	[15]	20	(508)	[17]	22	(559)	[19]
750	17	(432)	[14]	19	(483)	[16]	22	(559)	[19]	24	(610)	[21]
800	18	(457)		20	(508)		22	(559)		24	(610)	
900	19	(483)		22	(559)		24	(610)		24	(610)	
1000	20	(508)		…			…			…		
1250	22	(559)		…			…			…		
1500-2000	24	(610)		…			…			…		

*Bending space at terminals shall be measured in a straight line from the end of the lug or wire connector (in the direction that the wire leaves the terminal) to the wall, barrier, or obstruction.

For removable wire terminals intended for only one wire, bending space shall be permitted to be reduced by the number of inches shown in brackets.

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Table 7–11
WIRE BENDING SPACE, INCHES (MILLIMETERS), FOR ALL OTHER CONDUCTORS NOT COVERED BY TABLE 7-10 (MOTOR CONTROL CENTERS)

Size of Wire	Wires per Terminal				
AWG or MCM	1	2	3	4	5
14-10 AWG	Not	...	...	...	...
8-6	1½ (38)	...	...	...	...
4-3	2 (51)	...	...	...	...
2	2 ½ (64)	...	...	...	...
1	3 (76)	...	...	...	...
0-00	3 ½ (89)	5 (127)	7 (178)	...	...
000-0000 MCM	4 (102)	6 (152)	8 (203)	...	...
250	4 ½ (114)	6 (152)	8 (203)	10 (254)	...
300-350	5 (127)	8 (203)	10 (254)	12 (305)	...
400-500	6 (152)	8 (203)	10 (254)	12 (305)	14 (356)
600-700	8 (203)	10 (254)	12 (305)	14 (356)	16 (406)
750-900	8 (203)	12 (305)	14 (356)	16 (406)	18 (457)
1000-1250	10 (254)	...	...	...	...
1500-2000	12 (305)	...	...	...	...

NOTE: Bending space at terminals shall be measured in a straight line from the end of the lug or wire connector (in the direction that the wire leaves the terminal) to the wall, barrier, or obstruction.

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