National Electrical Manufacturers Association
2101 L Street, N.W. Suite 300
Washington, D.C. 20037 (202) 457-8400

PROPOSED, NEW AND REVISED STANDARDS

TO ALL REPRESENTATIVES OF MEMBER COMPANIES
IN THE INDUSTRIAL CONTROL AND SYSTEMS SECTION

Subject: Revision No. 1 to NEMA Standards Publication No. ICS 6-1988,
Enclosures for Industrial Control and Systems

Dear Representative:

At its March 1, 1989 meeting, the Codes and Standards Committee approved Revision 1 of Publication ICS 6-1988. This revision changes Paragraph 2.1.

Attached is the revision, including a new title page.

Please insert these pages and remove the pages that they replace.

Sincerely,

Krystyna A. McIver

Krystyna A. McIver
Standards Publications Editor

Encl: Revision 1 to ICS 6-1988
cc: All known holders of ICS 6-1988

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ICS 6

ENCLOSURES FOR INDUSTRIAL CONTROL AND SYSTEMS

Revision No. 1—March 1989

Published by

National Electrical Manufacturers Association
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ENCLOSURES FOR INDUSTRIAL CONTROL AND SYSTEMS

Section 1
REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

In this publication, reference is made to the standards listed below:

American National Standards Institute
1430 Broadway
New York, NY 10018

C80.5–1983 *Fittings for Rigid Metal Conduit and Electrical Metallic Tubing*

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

B1.20.1–1983 *Pipe Threads (General Purpose)*

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

C22.2-0–M–1982 *General Requirements for the Canadian Electrical Code*
C22.2–0.5–1982 *Threaded Conduit Entries*

National Electrical Manufacturers Association
2101 L Street, N.W.
Washington, DC 20037

ICS 1–1988 *General Standards for Industrial Control Systems*
250–1985 *Enclosures for Electrical Equipment (1000 Volts Maximum)*

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

70–1987 *National Electrical Code*

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

508–1984 *Electric Industrial Control Equipment*
698–1984* *Electric Industrial Control Equipment for Use in Hazardous Locations*

*Also available from American National Standards Institute

1.2 DEFINITIONS

The definitions NEMA Standards Publications ICS 1 and 250 apply to this Standards Publication unless otherwise indicated.

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Section 2
GENERAL

The Standards in this Section apply to all other parts in the Standards for Industrial Control and Systems unless otherwise specified. The definitions and standards of NEMA Standards Publications ICS 1 and 250 also apply to these standards, except that the 1000-volt maximum limitation of NEMA 250 does not apply to enclosures for industrial control and systems.

2.1 ENCLOSURE REQUIREMENTS

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, 11, 12, and 13 as defined by NEMA Standards Publication No. 250.

Enclosure types for products within the scope of the Industrial Control and Systems Section shall meet all the requirements of the 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.

NEMA Standard 3-1-1989.

2.2 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.

Authorized Engineering Information 3-17-1976.

2.3 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.

The enclosure design test procedures shall establish the external environmental limits for the enclosure. (See Part 108 of ICS 1.)

NEMA Standard 5-16-1984.

2.4 TYPE 9 AND TYPE 12 VENTILATED ENCLOSURES

Enclosure Types 9 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.

Authorized Engineering Information 5-16-1984.

2.5 USUAL SERVICE CONDITIONS

The enclosure design test procedures shall establish the external environmental limits for the enclosure.(See Part 108 of ICS 1.)

NEMA Standard 5-16-1984.

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STANDARDS PUBLICATION NO. ICS 6

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Enclosures for Industrial Control and Systems

NEMA

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ICS 6

ENCLOSURES FOR INDUSTRIAL CONTROL AND SYSTEMS

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TABLE OF CONTENTS

		Page
	FOREWORD	i
	SCOPE	iii
Section 1	REFERENCED STANDARDS AND DEFINITIONS	
	Referenced Standards	1
	Definitions	1
Section 2	GENERAL	
	Enclosure Requirements	2
	Legends	2
	Type Designations	2
	Type 9 and Type 12 Ventilated Enclosures	2
	Usual Service Conditions	2
Section 3	MANUFACTURING	
	Provisions for Conduit	3
	Threaded Conduit Hubs	3
	Threaded Holes for Rigid Conduit	3
	Knockouts	9
	Knockout Diameters and Conduit Bushing Dimensions	9
	Wire-Bending Space	10
	Ventilating Openings	12
	Design Test	12
	Minimum Screen Wire Size	12
	Minimum Thickness of Perforated or Expanded Sheet Metal	12
	Cast Metal Enclosures	12
	Nonmetallic Enclosures	12
	Sheet Metal Enclosures	13
	Screen Enclosures	13
	Electrical Spacings	13
	Securing Means	13
	Enclosure Grounding	13

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Foreword

This Standards Publication, together with the others listed below, supersedes and revises the indicated Standards Publications of the Industrial Control and Systems Section. Also included in these publications is the information separately printed as NEMA Standards Publication No. ICS 2.1-1983, *Seismic Testing of Motor Control Centers;* and Standards Publication No. ICS 2.2-1983, *Maintenance of Motor Controllers After a Fault Condition.* Standards Publication No. ICS 3.1-1983, *Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems,* is a supplement to Standards Publication No. ICS 3-1983 and is not included.

Since Standards Publication No. ICS 1 applies as a general standard and Standards Publication No. ICS 6 applies to enclosures used for control and systems apparatus, these two standards should be used in conjunction with each of the product standards.

Standards Publication No.	Supersedes
ICS 1-1988, *General Standards for Industrial Control and Systems*	ICS 1-1983, formerly Part 1 (white pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 2-1983, *Industrial Control Devices, Controllers and Assemblies*	ICS 2-1978, formerly Part 2 (green pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 3-1983, *Industrial Systems*	ICS 3-1978, formerly Part 3 (yellow pages) of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*
ICS 4-1983 (R 1988), *Terminal Blocks for Industrial Control Equipment and Systems*	ICS 4-1977, formerly NEMA Standards Publication No. IS 4-1968, *Terminal Blocks for Industrial Control Equipment and Systems*
ICS 6-1988, *Enclosures for Industrial Controls and Systems*	ICS 6-1983, formerly NEMA Standards Publication No. IS 1.1-1977, *Enclosures for Industrial Controls and Systems,* and Part ICS 1-110 of NEMA Standards Publication No. ICS-1970, *Industrial Controls and Systems*

In July 1988 unrevised portions of NEMA Standards Publication ICS 6-1983 were reaffirmed.

This Standards Publication provides practical information concerning ratings, construction, tests, 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.

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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:

1. Environmental conditions
2. System design
3. Equipment selection and application
4. Installation
5. Operating practices
6. Maintenance

To continue to serve the best interest of users of Industrial Control and Systems equipment, the Industrial Control and Systems Section is actively cooperating with other standardization organizations in the development of simple and more univeral 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.

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 publicaiton does not by itself assure a safe installation. When, however, equipment conforming with these standards is properly selected and is installed in accordance with the *National Electrical Code* and properly maintained, the hazards to persons and property will be reduced.

NEMA Standards Publications are subject to periodic review. They are revised frequently to reflect user input and meet changing conditions and technical progress. Users should secure the latest editions. See the postal return card attached to the front cover of the Standards Publication for the proper procedure to obtain revision service for your copy of the publication.

Proposed revisions to this Standards Publication should be submitted to:

Manager, Engineering Department
National Electrical Manufacturers Association
2101 L Street, N.W., Suite 300
Washington, DC 20037

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Scope

The NEMA Standards Publications for Industrial Control and Systems cover the requirements for all industrial control apparatus except as modified below. These standards cover all devices, whether electric, magnetic, mechanical, or electronic (except those devices intended specifically for marine auxiliaries and propulsion control apparatus, mine locomotive control apparatus, and railway and railroad locomotion), which, individually or grouped, serve to govern in some predetermined manner the electric power delivered to the apparatus to which they are connected, and which are intended to function on commercial voltages of 750 volts or less, direct current; and 7200 volts or less, alternating current.

The product scopes of the various Groups of the Industrial Control and Systems Section of NEMA who participated in the development of this Standards Publication No. ICS 6 are as follows:

I
Scope of Industrial Control Group

General purpose mechanical, electromechanical and/or solid state (static) devices and control which are principally used in industrial applications for the control of motors or other power utilization apparatus rated not more than 750 volts dc or 7,200 volts ac. The product scope specifically includes, but is not limited to, devices principally used for the following purposes:

A. To start, stop, protect, accelerate, decelerate, reverse, and/or control the speed of electric motors.

B. To provide some mechanical movement through the action of magnets or solenoids.

Examples of devices falling within this product scope are as follows:

1. Manual, magnetic, and solid state (static) starters and controllers
2. Relays and contactors, magnetic and solid state (static)
3. Drum switches
4. Overload devices intended primarily for the starting and running protection of electric motors, including inherent overload protective devices
5. Rheostats and resistors
6. Autotransformers and reactors of the type principally used in reduced voltage starters
7. Control circuit and/or pilot devices including, but not limited to, timers, push-buttons, indicating and pilot lights, limit switches, pressure, vacuum, temperature, or liquid-level switches, or both, plugging switches, speed switches, solenoids and photo-electric relays. Specifically includes domestic water pump pressure switches
8. AC and DC brakes, clutches, and electrical operators therefor
9. Resistance dimmers, autotransformer dimmers, reactor dimmers, and solid state (static) dimmer systems
10. Solid state logic devices
11. Machine tool and similar machine control panels.

II
Scope of Industrial Systems Group

A. Systems and devices not falling within the product scope of the Control Group, principally used in industrial applications for regulating power utilization apparatus. These systems are assemblies or groups of components arranged to include one or more feedback loops. These systems may include, when necessary to the operation of the system, data logging, data processing, and programming input components, even though they may not be in a feedback loop.

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B. AC and DC adjustable-speed drive systems and other systems of similar characteristics whether regulated or unregulated.

This product scope specifically includes, but is not limited to:

1. Adjustable-speed systems of the automatically-regulated type, such as: rolling mill drives, paper mill drives, slasher drives. These include systems for regulating speed, tension, current, and so forth
2. Machine tool control incorporating:
   a. Programmed input
   b. Feedback control of speed, position torque, and so forth
   c. Data logging and processing in feedback loops or as readouts
3. Computer control of machines
4. Industrial process regulating systems, excluding systems used solely for the control of temperature
5. Register and synchronizing control
6. Integrated mill control, including data logging, data processing, and programming
7. Automatic warehousing, including control of warehouse conveyors, automatic stackers, and so forth
8. Adjustable-speed mill systems
9. Analog-digital converters and transducers
10. Digital display devices
11. Semiconductor power converters and inverters for adjustable speed motors
12. Energy management systems.

Certain classes of equipment are **not** included in the product scope. Examples of these are:

1. Elementary feedback loop combinations of components, such as:
   a. Float switch, motor starter, motor, and pump
   b. Limit switches, reversing controller, motor, machine table
   c. Pressure switch, motor starter, motor, and compressor
   d. Light dimmers
2. Relay-type interlock systems not a part of the regulating system, such as relay banks for interlocking related operations of machines. For example: machine tool relay panels, steel mill auxiliary relay, and contactor panels
3. Unregulated constant potential mill auxiliaries
4. Specific components utilized in these systems and covered by the product scopes of other NEMA sections.

In this product scope, a component is a functional element of a system, i.e., operational amplifier, computer element, encoder, tape reader, gauging equipment.

III
Scope of Resistance Welding Control Group

Control principally used to start, stop and/or control, the operations of resistance welding machines.

Excluded from the product scope of this Section are:

1. Automatic electric controls and panels of the types principally used in air-conditioning, refrigeration, and comfort heating, which are in the scope of the Residential Controls Section
2. Motors, generators, and motor-generators which function as control when constituting part of adjustable-speed drives
3. Controls of the type used specifically for railway and railroad locomotion
4. Renewal parts
5. Data logging and processing equipment other than industrial
6. Temperature and humidity control.

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ENCLOSURES FOR INDUSTRIAL CONTROL AND SYSTEMS

Section 1
REFERENCED STANDARDS AND DEFINITIONS

1.1 REFERENCED STANDARDS

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American Society of Mechanical Engineers
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New York, NY 10017

B1.20.1–1983 *Pipe Threads (General Purpose)*

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

C22.2-0–M–1982 *General Requirements for the Canadian Electrical Code*
C22.2–0.5–1982 *Threaded Conduit Entries*

National Electrical Manufacturers Association
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Washington, DC 20037

ICS 1–1988 *General Standards for Industrial Control Systems*
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National Fire Protection Association
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70–1987 *National Electrical Code*

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333 Pfingsten Road
Northbrook, IL 60062

508–1984 *Electric Industrial Control Equipment*
698–1984* *Electric Industrial Control Equipment for Use in Hazardous Locations*

*Also available from American National Standards Institute

1.2 DEFINITIONS

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Section 2
GENERAL

The Standards in this Section apply to all other parts in the Standards for Industrial Control and Systems unless otherwise specified. The definitions and standards of NEMA Standards Publications ICS 1 and 250 also apply to these standards, except that the 1000-volt maximum limitation of NEMA 250 does not apply to enclosures for industrial control and systems.

2.1 ENCLOSURE REQUIREMENTS

Enclosure types for products within the scope of the Industrial Controls and Systems Section shall be Types 1, 2, 3, 3R, 3S, 4, 4X, 6, 6P, 7, 8, 9, 10, 11, 12, and 13 as defined by NEMA Standards Publication No. 250.

Enclosure types for products within the scope of the Industrial Control and Systems Section shall meet all the requirements of the 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.

NEMA Standard 5-16-1984.

2.2 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.

Authorized Engineering Information 3-17-1976.

2.3 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.

The enclosure design test procedures shall establish the external environmental limits for the enclosure. (See Part 108 of ICS 1.)

NEMA Standard 5-16-1984.

2.4 TYPE 9 AND TYPE 12 VENTILATED ENCLOSURES

Enclosure Types 9 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.

Authorized Engineering Information 5-16-1984.

2.5 USUAL SERVICE CONDITIONS

The enclosure design test procedures shall establish the external environmental limits for the enclosure.(See Part 108 of ICS 1.)

NEMA Standard 5-16-1984.

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Section 3
MANUFACTURING

The Standards in this Section apply to all other parts in the Standards for Industrial Control and Systems unless otherwise specified. The definitions and standards of NEMA Standards Publications ICS 1 and 250 also apply to these standards, except that the 1000-volt maximum limitation of NEMA 250 does not apply to enclosures for industrial control and systems.

Section 3 constitutes the Industrial Control and Systems manufacturing standards for enclosures as referenced in Part 6 of NEMA Standards Publication 250.

3.1 PROVISIONS FOR CONDUIT

3.1.1 Threaded Conduit Hubs

When made, the conduit entrance for type 3, 3R, 3S, 4, 4X, 6, 7, 8, 9, 10, and 11 enclosures shall be in the top and in the bottom of the enclosure. When provisions are made for threaded conduit connections in these enclosures for alternating current controllers size 5 or smaller, there shall be one ¾-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 wires and one conduit entrance in the bottom of manual and magnetic controllers for load wires in accordance with Table 3-1.

NEMA Standard 11-14-1985.

Table 3-1
CONDUIT SIZES FOR CONTROLLERS[1]

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

[1]The values given are based on the use of wires whose insulation is rated either 60°C or 75°C.

3.1.2 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.

Tapered pipe threads 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.

Table 3-2 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 3-2 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 3-1. Some recommended hole sizes for rigid conduit threads with integral bushings are shown in Table 3-3. The sizes shown permit tapping to meet the ANSI requirements of Table 3-2.

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 3-4 so that sufficient threads will protrude through the wall for attachment of a separate bushing, without requiring additional threading of the conduit.

Authorized Engineering Information 5-16-1984.

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Table 3-2
INTERNAL THREAD REQUIREMENTS FOR RIGID CONDUIT IN ENCLOSURES WITH INTEGRAL BUSHINGS

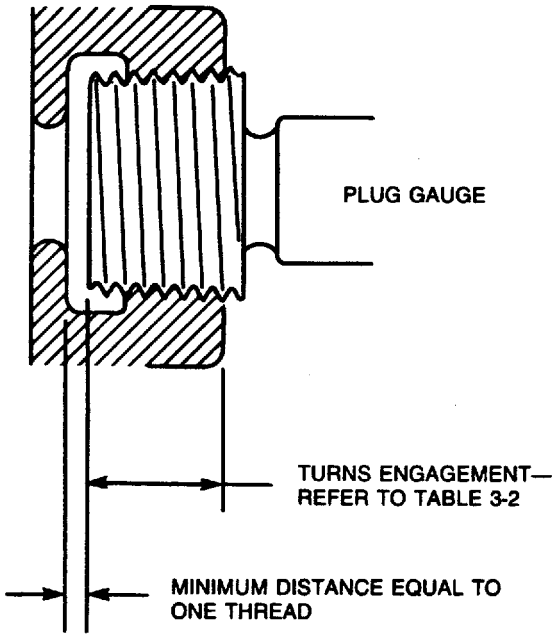
Nominal or Trade Size of Conduit, Inches	Threads per Inch	American National Standards Insitute Publications					Canadian Standards Association Publications					
		Applicable to All ANSI		Min. Threads Engaged			CSA C22.2-0-M[3] Min. Threads Engaged		CSA C22.2-0.5			
		Min. Turns Pene-tration[1]	Max. Turns Pene-tration[1]	ANSI C80.5[2]	ANSI C33.76 (UL 508)	ANSI C33.30 (UL 698)	Other Than Class I Loc.	Class I Haz. Loc.	Min. Turns Pene-tration[1]	Max. Turns Pene-tration[1]	Min. Threads Engaged: Other Than Class I Loc.	Min. Threads Engaged: Class I Haz. Loc.
½	14	6	9	5	3½	5	3½	5	5	7	3½	5
¾	14	6	9	5	3½	5	3½	5	5¼	7¼	3½	5
1	11½	6	9	5	3½	5	3	5	5⅛	7⅛	3	5
1¼	11½	6	10	5	3½	5	3	5	5⅜	7⅜	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	9¼	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

[1] As gauged with a working guage complying with Secion 7 of ANSI B1.20.1.

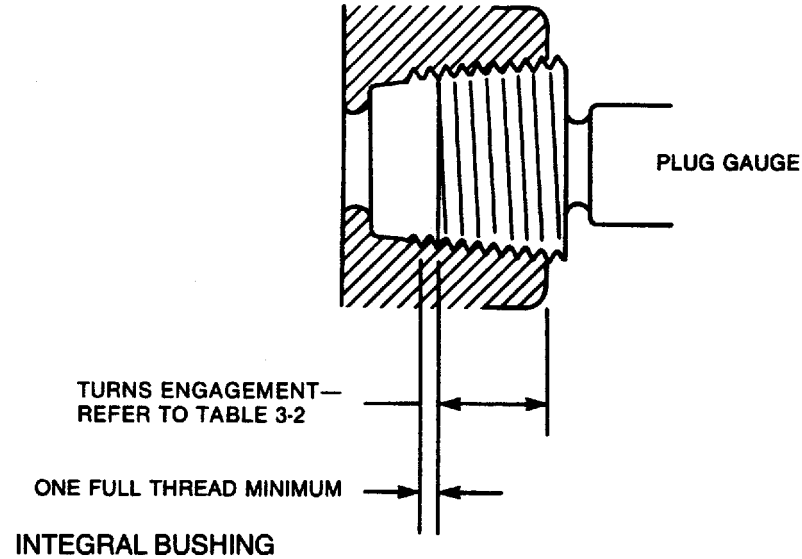
[2] ANSI C80.5 requires five full threads engagement unless otherwise specified.

[3] CSA C22.2-0-M does not specify thread fit.

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INTEGRAL BUSHING
WITH UNDERCUT



INTEGRAL BUSHING
WITHOUT UNDERCUT

Figure 3-1
THREADED HOLES
TURNS ENGAGEMENT METHOD OF GAUGING

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Table 3-3
RECOMMENDED DIMENSIONS (IN INCHES) FOR RIGID CONDUIT CONNECTIONS IN ENCLOSURES WITH INTEGRAL BUSHINGS

Nominal or Trade Size of Conduit	Threads per Inch	Without Undercut (Figure 3-2)		With Undercut (Figure 3-3)				Throat Diameter D3	
		Entrance Diameter D1	Depth L1	Entrance Diameter D1	Depth L1	Undercut Diameter D2	Undercut Depth L2	Min.	Max.
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

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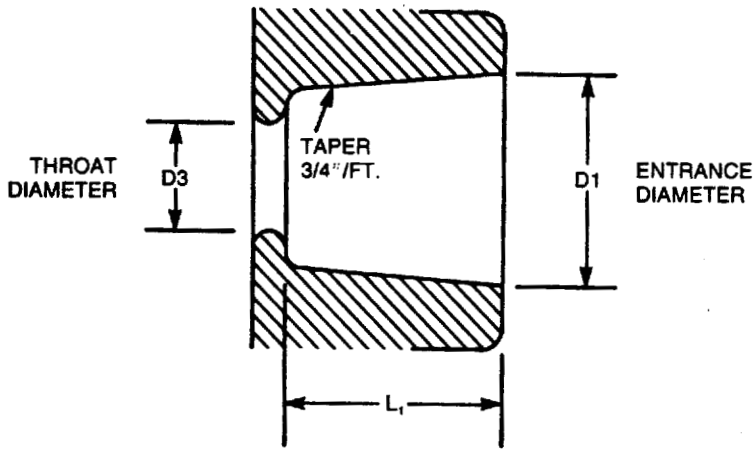


Figure 3-2
RIGID CONDUIT—
INTEGRAL BUSHING WITHOUT UNDERCUT

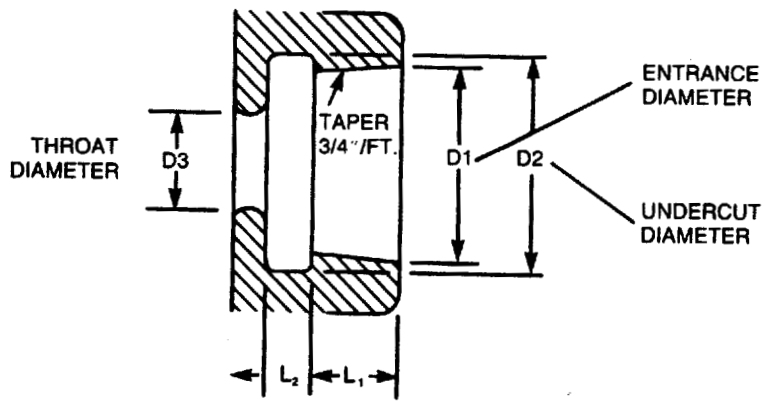


Figure 3-3
RIGID CONDUIT—
INTEGRAL BUSHING WITH UNDERCUT

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Table 3-4
HOLE SIZES AND WALL THICKNESSES (IN 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 ¼ in./ft.)	Enclosure Wall Thickness	
			Min.	Max.
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

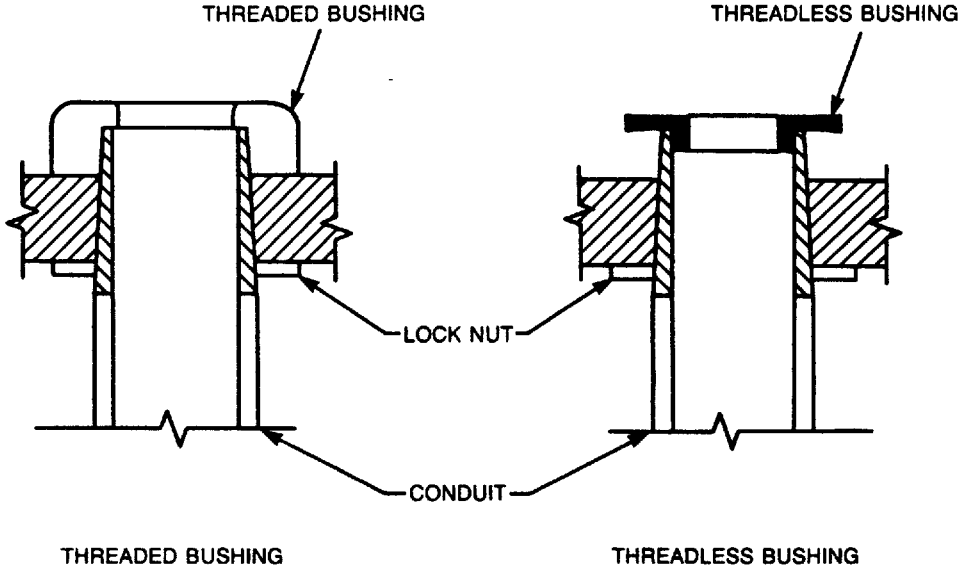


Figure 3-4
CONDUIT BUSHINGS

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3.1.3 Knockouts

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

NEMA Standard 5-16-1984.

3.2 KNOCKOUT DIAMETERS AND CONDUIT BUSHING DIMENSIONS

Table 3-6 shows the knockout diameters and conduit bushing dimensions to be taken into consideration when designing enclosures and mounting the enclosed apparatus.

Authorized Engineering Information 5-16-1984.

Table 3-5
RANGES OF WIRE AND KNOCKOUT SIZES

Controller Size	Range of Wire Sizes Required for Line and Load,[1] AWG or MCM		Knockouts for Three Line or Three Load Wires[2]	
	Copper	Aluminum	Range of Sizes of Conduit for Copper Wire Alone	Range of Sizes of Conduit for Aluminum and Copper Wire
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, 1¼
3	8-⅙	8-⅜	¾, 1, 1¼, 1½	¾, 1, 1¼, 1½, 2
4	4-⅜	2-250	1, 1¼, 1½, 2	1, 1¼, 1½, 2, 2½
5	⅜-500	⅘-700	1½, 2, 2½, 3	1½, 2, 2½, 3, 3½

[1] Derating factors for 60°C and 75°C wire in a 40°C ambient are 0.82 and 0.88, respectively, with not more than three conductors in raceway.
The maximum wire size shown is for a 40°C 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 75°C insulation in a 30°C ambient and minimum motor full load current corresponding to horsepower.

[2] Largest knockout is based on use of 60°C wire for controller sizes 00 through 3 and 75°C wire for controller sizes 4 and 5.

Table 3-6
KNOCKOUT DIAMETERS AND CONDUIT BUSHING DIMENSIONS

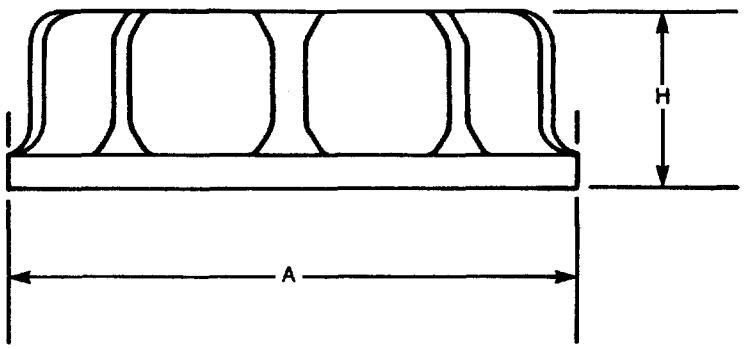
Nominal Size of Conduit, Inches	Knockout Diameter,[1] Inches			Bushing		
	Nominal[2]	Minimum	Maximum	Minimum Diameter at Flange,[3] Inches (Dimension A)	Minimum Over Knockout, Inches	Height, Inches (Dimension H)
1	2	3	4	5	6	7
½	0.875	0.859	0.906	1.00	0.033	0.375
¾	1.109	1.094	1.141	1.23	0.021	0.422
1	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

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

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

[3] 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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(ILLUSTRATION IS NOT A DESIGN DETAIL)

3.3 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 Tables 3-7A, 3-7B, and 3-7C.) 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 wire will be initially directed. If a conductor is restricted from bending, by means of barriers or otherwise, where it leaves the lug, the distance shall be measured from the end of the barrier.

NEMA Standard 11-20-1986.

Table 3-7A
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[1]
14-10	Not Specified	. . .
8-6	1½	. . .
4-3	2	. . .
2	2½	. . .
1	3	. . .
0	5	5
00	6	6
000-0000	7	7
250	8	8
300	10	10
350-500	12	12
600-700	14	16
750-900	18	19

[1] 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 3-7B
WIRE BENDING SPACE FOR CONDUCTORS LEAVING THE ENCLOSURE THRU THE WALL OPPOSITE THE TERMINALS (MOTOR CONTROL CENTERS)

Wire Size	Wires per Terminal			
	1	2	3	4 or more
14–10	Not specified	. . .	. . .	. . .
8	1½	. . .	. . .	. . .
6	2	. . .	. . .	. . .
4	3	. . .	. . .	. . .
3	3	. . .	. . .	. . .
2	3½	. . .	. . .	. . .
1	4½	. . .	. . .	. . .
0	5½	5½	7	. . .
2/0	6	6	7½	. . .
3/0	6½ (½)	6½ (½)	8	. . .
4/0	7 (1)	7½ (½)	8½ (½)	. . .
250	8½ (2)	8½ (2)	9 (1)	10
300	10 (3)	10 (2)	11 (1)	12
350	12 (3)	12 (3)	13 (3)	14 (2)
400	13 (3)	13 (3)	14 (3)	15 (3)
500	14 (3)	14 (3)	15 (3)	16 (3)
600	15 (3)	16 (3)	18 (3)	19 (3)
700	16 (3)	18 (3)	20 (3)	22 (3)
750	17 (3)	19 (3)	22 (3)	24 (3)
800	18	20	22	24
900	19	22	24	24
1,000	20	. . .	. . .	. . .
1,250	22	. . .	. . .	. . .
1,500	24	. . .	. . .	. . .
1,750	24	. . .	. . .	. . .
2,000	24	. . .	. . .	. . .

For SI units: one inch = 25.4 millimeters.

Bending space at terminals shall be measured in a straight line from the end of the lug or wire connector in a direction perpendicular to the enclosure wall.

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

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Table 3-7C
WIRE BENDING SPACE FOR ALL OTHER CONDUCTORS NOT COVERED BY TABLE 3-7B (MOTOR CONTROL CENTERS)

AWG or Circular-Mil Size of Wire	Wires per Terminal				
	1	2	3	4	5
14–10	Not Specified	. . .	. . .	. . .	. . .
8–6	1½	. . .	. . .	. . .	. . .
4–3	2	. . .	. . .	. . .	. . .
2	2½	. . .	. . .	. . .	. . .
1	3	. . .	. . .	. . .	. . .
0–00	3½	5	7	. . .	. . .
000–0000	4	6	8	. . .	. . .
250 MCM	4½	6	8	10	. . .
300–350 MCM	5	8	10	12	. . .
400–500 MCM	6	8	10	12	14
600–700 MCM	8	10	12	14	16
750–900 MCM	8	12	14	16	18
1,000–1,250 MCM	10	. . .	. . .	. . .	. . .
1,500–2,000 MCM	12	. . .	. . .	. . .	. . .

For SI units: one inch = 25.4 millimeters.
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.

3.4 VENTILATING OPENINGS

3.4.1 Design Test

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.

3.4.2 Minimum Screen Wire Size

When openings are screened, the wire gauge of the screen shall be not less than No. 16 AWG. When the screen mesh openings are greater than ½ square inch in area, the wire gauge shall be not less than No. 12 AWG.

3.4.3 Minimum Thickness of 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 minimum if steel and 0.058 inch if nonferrous. When the mesh openings or perforations are greater than ½ square inch in area, the thickness of the metal shall be not less than 0.080 inch minimum if steel and 0.112 inch if nonferrous.

In a small device where the indentation of a guard or enclosure will not affect the clearance between uninsulated movable current-carrying parts and grounded metal, 0.020 inch steel or 0.029 inch nonferrous expanded metal mesh is permitted to be employed, provided that either:

(a) The exposed mesh on any one side of the surface of the device, which is so protected has an area which is not greater than 72 square inches and has no dimension which is greater than 12 inches.
(b) The width of an opening so protected is not greater than 3½ inches.

NEMA Standard 5-16-1984.

3.5 CAST METAL ENCLOSURES

Cast metal, other than die-cast metal, shall be at least ⅛ inch thick at every point and of greater thickness at reinforcing ribs and door edges and shall be at least ¼ inch thick at threaded holes for conduit. Die-cast metal shall be not less than 3/32 inch thick for an area which is greater than 24 square inches or in which any dimension is greater than 6 inches and shall be not less than 1/16 inch thick for an area which is 24 square inches or less in which no dimension is greater than 6 inches and shall be at least ¼ inch thick at threaded holes for conduit.

NEMA Standard 3-17-1976.

3.6 NONMETALLIC ENCLOSURES

Polymeric enclosures shall be evaluated in accordance with UL 508.

NEMA Standard 5-16-1984.

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3.7 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 Tables 3-8 and 3-9; and, at points where conduit or armored cable is connected, not less than 0.032 inch if of steel and not less than 0.045 inch if of nonferrous metal. For large enclosures, such as those used for complex multi-component controllers, where the enclosure surface does not contribute to the structural integrity of the enclosure and deformation would not increase electrical hazards, Tables 3-8 and 3-9 do not apply.

NEMA Standard 5-16-1984.

3.8 SCREEN ENCLOSURES

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

NEMA Standard 3-17-1976.

3.9 ELECTRICAL SPACINGS

Spacings between any live part and the enclosure wall shall be as shown in Part ICS 1-111 of NEMA Standards Publication No. ICS 1, 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 Part ICS 1-111 if the enclosure is lined with an insulating material.

NEMA Standard 5-16-1984.

3.10 SECURING MEANS

Parts of enclosures such as doors, covers, tanks, and so forth shall be provided with means for firmly securing them in place.

NEMA Standard 3-17-1976.

3.11 ENCLOSURE GROUNDING

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

NEMA Standard 5-16-1984.

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

Authorized Engineering Information 10-29-1979.

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 conduit and all metallic parts which project through the enclosure.

NEMA Standard 5-16-1984.

If a grounding wire is furnished by the apparatus manufacturer, it should be green with or without a yellow stripe. If 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.

Authorized Engineering Information 10-29-1979.

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Table 3-8
THICKNESS OF CARBON OR STAINLESS-STEEL SHEET-METAL ENCLOSURES— MAXIMUM DIMENSIONS OF ANY SURFACE, INCHES

Without Supporting Frame[1]		With Supporting Frame or Equivalent Reinforcing[1]		Minimum Thickness	
Maximum Width[2]	Maximum Length[3]	Maximum Width[2]	Maximum Length	Uncoated	Zinc Coated
4.0	Not limited	6.25	Not limited	0.020[4]	0.023[4]
4.75	5.75	6.75	8.25	0.020[4]	0.023[4]
6.0	Not limited	9.5	Not limited	0.026[4]	0.029[4]
7.0	8.75	10.0	12.5	0.026[4]	0.029[4]
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

[1] 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.

[2] 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.

[3] "Not limited" applies only if the edge of the surface is flanged at least ½ inch or fastened to adjacent surfaces not normally removed in use.

[4] Sheet steel for an enclosure intended for outdoor use shall be not less than 0.034 inch thick if zinc coated and not less than 0.032 inch thick if uncoated.

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Table 3-9
THICKNESS OF ALUMINUM, COPPER, OR BRASS SHEET-METAL ENCLOSURES— MAXIMUM DIMENSIONS OF ANY SURFACE, INCHES

Without Supporting Frame[1]		With Supporting Frame or Equivalent Reinforcing[1]		
Maximum Width[2]	Maximum Length[3]	Maximum Width[2]	Minimum Length	Minimum Thickness of Sheet
3.0	Not limited	7.0	Not limited	0.023[4]
3.5	4.0	8.5	9.5	0.023[4]
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	123.0	Not limited	0.153
60.0	74.0	130.0	160.0	0.153

[1] 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.

[2] 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.

[3] "Not limited" applies only if the edge of the surface is flanged at least ½ inch or fastened to adjacent surfaces not normally removed in use.

[4] Sheet copper, brass, or aluminum for an enclosure intended for outdoor use shall be not less than 0.029 inch thick.

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status, are set forth in certain clauses of the NEMA *Standardization Policies and Procedures* manual and are referenced below.

Purpose of Standards

National Electrical Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of a National Electrical Manufacturers Association Standard does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the standard. *(Standardization Policies and Procedures, p. 1)*

Definition of a Standard

A standard of the National Electrical Manufacturers Association defines a product, process, or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, rating, testing, and the service for which they are designed.

(Standardization Policies and Procedures, p. 2)

Dimensions

Where dimensions are given for interchangeability purposes, alternate dimensions satisfying the other provisions of the standards publication may be capable of otherwise equivalent performance.

(Standardization Policies and Procedures, p. 9)

Classes of Standards

National Electrical Manufacturers Association Standards are of two classes:

1. NEMA Standard, which relates to a product commercially standardized and subject to repetitive manufacture, which standard has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon;
2. Suggested Standard for Future Design, which may not have been regularly applied to a commercial product, but which suggests a sound engineering approach to future development, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

Authorized Engineering Information

Authorized Engineering Information consists of explanatory data and other engineering information of an informative character, not falling within the classification of NEMA Standard or Suggested Standard for Future Design, which standard has been approved by at least two-thirds of the members of the Subdivision eligible to vote on the standard.

(Standardization Policies and Procedures, pp. 8 & 17)

Official Standards Proposal

An Official Standards Proposal is an official draft of a proposed standard which is formally recommended to an outside organization(s) for consideration, comment, and/or approval, and which has been approved by at least 90 percent of the members of the Subdivision eligible to vote thereon.

(Standardization Policies and Procedures, pp. 8 & 17)

Identification of Status

Standards in NEMA Standards Publications are identified in the foreword or following each standard as "NEMA Standard" or "Suggested Standard for Future Design." These indicate the status of the standard. These words are followed by a date which indicates when the standard was adopted in its present form by the Association.

The material identified as "Authorized Engineering Information" and "Official Standards Proposal" is designated similarly.

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Nelson Electric Unit
Tulsa, OK 74101

G & L Electronics
Fond du Lac, WI 54935

Gould, Inc.
Industrial Automation Systems Group
North Andover, MA 01845

GTE Products Corporation
Control Device Operation
Standish, ME 04084

Harnischfeger Corporation
Milwaukee, WI 53201

Honeywell, Inc.
Industrial Programmable Control Div.
York, PA 17405-0934

Hubbell Incorporated
Industrial Controls Division
Madison, OH 44057

Joslyn Clark Controls Inc.
Lancaster, SC 29720

Klockner-Moeller Corporation
Natick, MA 01760

The Kohler Company
Kohler, WI 53044

Kulka Smith, Inc.
Manasquan, NJ 08736

McGill Manufacturing Company, Inc.
Valparaiso, IN 46383

Micro Switch
Division of Honeywell, Inc.
Freeport, IL 61032

Namco Controls Division
An Acme Cleveland Company
Mentor, OH 44060

Onan Corporation
Minneapolis, MN 55432

Pass & Seymour, Inc.
Syracuse, NY 13221

The Planum Technology Corporation
Hillside, NJ 07205

Reliance Electric Company
Athens, GA 30613-1299

Robicon Corporation
Pittsburgh, PA 15239

Russelectric Inc.
Hingham, MA 02043

Siemens Energy & Automation, Inc.
Atlanta, GA 30346-9000

Sprecher & Schuh, Inc.
S & S Controls Division
Houston, TX 77060

Square D Company
Palatine, IL 60067

R. Stahl, Inc.
Woburn, MA 01801

Telemecanique, Incorporated
Westminster, MD 21157

Texas Instruments, Inc.
Attleboro, MA 02703

Toshiba International Corporation
Houston, TX 77041

Turck Multiprox, Inc.
Minneapolis, MN 55441-0630

Underwriters Safety Device
An Allied Company
Chicago, IL 60656

Weidmuller, Inc.
Richmond, VA 23236

Westinghouse Electric Corporation
Pittsburgh, PA 15222

Zenith Controls, Incorporated
Chicago, IL 60609

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