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safety standards for construction and guide for selection, installation and operation of adjustable-speed drive systems

NEMA

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ● 2101 L STREET, N.W., WASHINGTON, D.C. 20037

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SAFETY STANDARD FOR CONSTRUCTION AND GUIDE FOR SELECTION, INSTALLATION AND OPERATION OF ADJUSTABLE-SPEED DRIVE SYSTEMS

Foreword

In the preparation of this Standards Publication, input of users and other interested parties has been sought and evaluated.

It is general knowledge that the misuse of electricity is potentially hazardous and may create risks to personnel and property. In addition to shocks or burns from direct contact with live parts, the risks may also include: (1) fire resulting from overloads, faulty wiring or faulty equipment, and (2) injuries resulting from erratic machine operation. The degree of hazard can be greatly reduced by proper design, construction, selection, installation and use, but hazards cannot be completely eliminated. The reduction of hazard should be the joint responsibility of the user and the manufacturers of: (1) the driven equipment, (2) the motor or motors, and (3) the electrical equipment for supplying and controlling the power for the motor or motors.

Since any electrical equipment can be installed or operated in such a manner that hazardous conditions can occur, compliance with this publication does not by itself assure a safe installation. However, when equipment complying with this publication is properly selected with respect to the driven load and environment and is installed in accordance with the *National Electrical Code*, the potential hazards to persons and property will be reduced.

The importance of communication between manufacturer and user cannot be overemphasized. The chances for preventing hazardous incidents and limiting their consequences are greatly improved when both user and manufacturer are correctly and fully informed with respect to the intended use and all environmental and operating conditions.

The purpose and scope of this Standards Publication are given on Page ii. The book consists of the following parts:

Part 1—Defines the term "control equipment" as used in Part 2.

Part 2—Defines construction details which contribute to safety. It is intended to assist the electrical manufacturer to design and build equipment with features which will reduce hazards and, also, to assist the user and the manufacturer of the driven equipment in the selection of electrical equipment which has been designed and built to include features that contribute to safety.

Part 3—Sets forth requirements for high-potential tests.

Part 4—Is intended to guide the user and the manufacturer of the driven equipment in the proper selection, installation and operation of adjustable-speed drive systems. Since the reduction of hazards depends greatly on how equipment is selected, installed and used, this section points out possible hazards and suggests ways and means to reduce them.

* * *

Publication No. ICS 3.1-1983 supersedes the NEMA Standards Publication for *Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems,* Publication No. ICS 3.1-1979. Prior to publication, the NEMA Standards, Suggested Standards for Future Design, and Authorized Engineering Information which appear in this publication unchanged since their appearance in ICS 3.1-1979 were reaffirmed.

Publication No. ICS 3.1-1983 supplements the NEMA Standards Publication for *Industrial Systems,* Publication No. ICS 3-1983.

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The purpose of this Standards Publication is to define the construction and test requirements for adjustable-speed drive systems and to provide recommendations for their selection, installation and operation in such manner as to provide for the practical safeguarding of persons.

Comments will be welcomed. They should be addressed to:

Manager, Engineering Department
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Scope

These standards apply to all industrial equipment electrical components and wiring which are part of the electrical drive system, commencing at the point of connection of input power to these components. They apply to open or enclosed electrical equipment for use on circuits which operate from an alternating-current supply voltage of 600 volts or less.

These standards are intended for industrial equipment which will be installed in accordance with the *National Electrical Code* and the manufacturers' instructions. They are not considered adequate for industrial equipment intended for use in locations which are designated as hazardous in the *National Electrical Code*, ANSI Publication No. C1(NFPA Publication No. 70).

These standards are generally applicable, but there may be situations where a conflict with other safety measures or operational requirements will necessitate that these standards be modified.

Excluded from this publication are:

(a) Portions, subassemblies or parts of motors or controllers to be used in the manufacture of more complete controllers or drive systems.
(b) Main propulsion equipment for railroad and transit locomotive cars.
(c) Automotive equipment.
(d) Equipment for airborne or aerospace craft.
(e) Equipment for household use.
(f) Equipment built to military specifications which conflict with or override the provisions of this publication.
(g) Additional specific features required for use under unusual service conditions, in locations involving hazardous atmospheres and hazardous projects.
(h) Systems for processes using electricity for purposes other than supplying and controlling electric motors.
(i) Drive system rated less than 1/4 horsepower.
(j) Drive systems for portable tools.
(k) Industrial electric trucks.
(l) Passenger elevators or moveable walkways or lifts.
(m) Marine equipment.

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Part 1
DEFINITIONS

ICS 3.1-1.01 CONTROL EQUIPMENT

The term "control equipment," as used throughout Part 2, denotes a single physical assembly which is installed as a separate part of an adjustable-speed drive system. A control equipment may consist of only one part, such as transformer, or may consist of a number of parts and associated wiring, such as a semiconductor power converter. A control equipment is generally assembled at the factory but may consist of a number of control panels, enclosures and other parts which are to be assembled into a single control equipment at the installation site.

NEMA Standard 3-17-1976.

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Part 2
CONSTRUCTION

ICS 3.1-2.01 CONTROL EQUIPMENT RATING AND IDENTIFICATION PLATES

.01 Control Equipment Nameplate

A legible, durable nameplate shall be attached to the control equipment and shall, as a minimum, include the data required by items a and b. If the control equipment requires power from a source external to the adjustable-speed drive system, the nameplate shall also list the data required by items c, d, and e.

(a) Manufacturer's name or identification number.
(b) Control equipment identification.
(c) Supply voltage, phase (if polyphase) and frequency (if alternating current).
(d) Maximum continuous input current or kVA. When multiple alternating-current inputs are employed for a given control cabinet, the full-load current for each input shall be indicated or referenced. (This does not apply to auxiliary control circuits requiring less than 15 amperes.) NEMA Standard 3-17-1976.
(e) Maximum permissible available symmetrical rms short-circuit current of incoming power source.

Suggested Standard for Future Design 3-17-1976.

.02 Motor Nameplates

(a) Alternating-current motors shall be identified in accordance with MG 1-10.38 of NEMA Publication No. MG 1.*
(b) Direct-current motors shall be identified in accordance with MG 1-10.65 of NEMA Publication No. MG 1.

.03 Device Identification

(a) Control and power devices shall be plainly identified, using the same identification as shown on the elementary diagram.
(b) All fuses shall be identified by their rating and by class or type on the panel immediately adjacent to the fuse.

EXCEPTION—Where space does not permit, the fuse may be indicated by a device symbol provided that it is clearly referenced as to its rating and class or type on the appropriate documentation.

NEMA Standard 3-17-1976.

ICS 3.1-2.02 OPERATING AND MAINTENANCE DATA

Instruction documents should be furnished and should include at least the following:

(a) Information necessary for calibrating components, devices and subassemblies which are intended to be adjusted by the user.
(b) Information to allow for the proper selection of the input circuit equipment and protection when an electronic power converter is designed for use in different applications with a range of load horsepower ratings.
(c) Operating instructions, including all information necessary to operate the complete drive system.
(d) Maintenance instructions, including information for locating and replacing faulty components or subassemblies.
(e) Appropriate warning notices where safety considerations exist.

Documents should be of such a size and quality as to be clearly legible. The format and symbols for diagrams should be in accordance with Part ICS 1-101, 1-102, or 1-103 of NEMA Publication No. ICS 1, as applicable.

Authorized Engineering Information 3-17-1976.

ICS 3.1-2.03 SUPPLY CIRCUIT DISCONNECTING DEVICES

.01 Scope

The requirements of ICS 3.1-2.03 apply to the disconnecting means required by the *National Electrical Code,* Section 430, Part H, if the devices used are supplied as a part of the control equipment.

If a device used for or as part of the disconnecting means is also used for any other function(s), such as overcurrent protection, the requirements of the other function(s) shall also be met.

NEMA Standard 3-17-1976.

The term "disconnecting means" has a very special meaning in the *National Electrical Code.* Care should be exercised in the use of this term to avoid misunderstanding. If a specific method of complying with the *National Electrical Code* for a particular application is required, it should be specified.

Authorized Engineering Information 3-17-1976.

.02 Type

The main power disconnecting means shall be a switch or circuit breaker which clearly indicates whether it is open or closed. Switches and circuit breakers which are normally power operated shall include means for manual opening and shall indicate when they have been opened manually. The devices need not indicate that they are in the tripped position when this position differs from the manually opened position.

*Refer to Appendix A for further information on all publications referenced in this publication.

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If the main power disconnecting device is mounted in a control equipment enclosure, the indication shall be visible outside of the enclosure.

NEMA Standard 3-17-1976.

Provisions for locking the disconnecting means may be necessary in order to comply with the *National Electrical Code,* Article 430-86, when the motor and driven machinery are not in sight from the control equipment.

Authorized Engineering Information 3-17-1976.

.03 Rating

The ampacity of the disconnecting means shall be not less than 115 percent of the maximum continuous current required for all equipment which may be in operation at the same time under normal conditions.

The load interrupting capacity of the disconnecting means shall be not less than the sum of the maximum operating overload current of the largest motor plus the full load current of all other connected operating equipment.

.04 Supply Conductors to be Disconnected

All ungrounded conductors of the motor power and control power supply circuits shall be disconnected by one disconnecting device or by adjacent disconnecting devices. Disconnection is not required for remotely energized control and signal conductors in industrial establishments where access is limited to qualified persons.

NEMA Standard 3-17-1976.

Additional precautions such as yellow wire or guarding should be considered for these remotely energized control and signal conductor circuits if they are rated above 50 volts.

Authorized Engineering Information 3-17-1976.

A warning label shall be provided adjacent to the operating handle of the main power disconnect if this disconnect does not deenergize all exposed live parts when it is in the "off" position.

.05 Connections to Supply Lines

The line terminals of all disconnecting means shall be guarded to remove the likelihood of approach or contact by persons or objects to a point of danger.

.06 Mounting

When the main power disconnecting means is mounted within the control equipment enclosure, its operating handle shall be externally operable.

NEMA Standard 3-17-1976.

Where two sources of main power (e.g., alternating and direct current) are required for a control equipment, separate disconnecting means may be employed for each type of power provided:

(a) The disconnecting means are grouped adjacent to each other.
(b) An external handle is provided for each disconnecting means which is enclosed.

Authorized Engineering Information 3-17-1976.

.07 Operating Handle

When the external operating handle of the disconnecting device is in its highest position, the center of the grip shall be not more than 6-1/2 feet above the floor.

If locking means are provided, the operating handle shall be so arranged that it can be locked only in the "off" position.

EXCEPTION—When specified for applications for which opening may create a hazard, locking means shall also be arranged for locking in the "on" position.

.08 Isolation

The following requirements apply to any power isolating switch or circuit breaker that is furnished to isolate a portion of the electrical equipment of a drive system and that is not any part of the supply circuit disconnecting means required by the *National Electrical Code*, Article 430, Part 4:

(a) Where the isolating means is not intended to interrupt load current, a warning label shall state DO NOT OPEN UNDER LOAD.
(b) If the isolating means is mounted in an equipment enclosure with the operating handle externally operable, a warning label shall be provided adjacent to the operating handle stating that it does not disconnect all power from the equipment.

NEMA Standard 3-17-1976.

Where a control circuit disconnect may be confused with power circuit disconnects due to size or location, a warning label should be provided adjacent to the operating handle of the control circuit disconnect stating that it does not disconnect all power from the equipment.

Authorized Engineering Information 3-17-1976.

ICS 3.1-2.04 PROTECTION

.01 Interrupting Capacity

Devices which are intended to break short-circuit current shall have an interrupting capacity sufficient for the voltage used and for the current that must be interrupted when the control equipment or drive system is connected to a power supply having the capacity to apply maximum voltage and maximum available short-circuit current within the limits specified for the equipment.

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.02 Control Circuit

(a) *Transformer*—The control circuit transformer shall be protected against overloads and short circuits by an overcurrent protection device in the primary or secondary circuit. Where the secondary circuit is grounded, the overcurrent protective devices shall be located only in the ungrounded conductors. The overcurrent devices shall interrupt when the sustained current exceeds 125 percent of the rated current of the control transformer and shall interrupt short circuits without damage to the control transformer or conductors.

EXCEPTION 1—When 125 percent of the rated current of the control transformer does not correspond to a standard rating of the overcurrent device, the next higher standard rated device may be used.

EXCEPTION 2—Transformers supplying power only to circuits that do not extend beyond the control equipment do not require overcurrent protection.

EXCEPTION 3—Overcurrent devices are not required for transformers for limited energy circuits which, in accordance with Section 725 of the *National Electrical Code*, do not require overcurrent protection.

(b) *Conductors*—Where a control circuit transformer is used to supply a control circuit that extends beyond the control equipment, an overcurrent device shall protect the control circuit conductors extending beyond the control equipment. The setting or rating of the overcurrent device shall not exceed 200 percent of the ampacity of the conductor.

EXCEPTION—Overcurrent devices are not required for conductors for limited energy circuits which, in accordance with Section 725 of the *National Electrical Code,* do not require overcurrent protection.

(c) *Direct-current Motor Field Circuits*—Fusing of direct-current motor field circuit conductors is not required. However, if overcurrent protection of these conductors is used, provisions shall be made to prevent overspeed of the motor in the event of loss of field excitation.

NEMA Standard 3-17-1976.

.03 Undervoltage (Low-voltage) Protection

Undervoltage protection shall be required unless undervoltage release is specified. See par. ICS 3.1-4.05.02.a.

Suggested Standard for Future Design 3-17-1976.

.04 Motor Overload

Each motor and its motor branch circuit shall be protected against running overload as required by the *National Electrical Code,* Article 430, Section C.

NEMA Standard 7-12-1978.

Running overload protection means include, but are not necessarily limited to, the following:

(a) An individual overload device responsive to motor current.

(b) An overtemperature device mounted in the motor, and responsive to motor overtemperature.

It is recommended that reference be made to MG 1-12.75 in NEMA Publication No. MG 1 regarding the overtemperature protection of direct-current motors.

The motor overload protective devices may be included in the control equipment or mounted separately.

Authorized Engineering Information 3-17-1976.

The minimum number and location of overload devices, when used, shall be in accordance with the *National Electrical Code.*

The ratings or settings of overload devices shall be in accordance with the *National Electrical Code.*

NEMA Standard 3-17-1976.

Where power conversion equipment is used and a definite correspondence exists between input and output currents, overload protection can be provided by devices which are responsive to input or output currents or by a combination of devices.

Authorized Engineering Information 3-17-1976.

Resetting of an overload device shall not start the motor.

Suggested Standard for Future Design 3-17-1976.

Ratings for fuses for direct-current circuits should be selected with consideration given to their direct-current performance since fuse ratings may be based on alternating-current power.

Authorized Engineering Information 3-17-1976.

.05 Main and Branch-circuit Overcurrent (Short-circuit) Protection

Main incoming power circuits shall include overcurrent (short-circuit) protection.

NEMA Standard 3-17-1976.

The main circuit overcurrent protection may be provided with the equipment or at the time of installation.

Authorized Engineering Information 3-17-1976.

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An equipment which includes two or more controllers and a feeder bus supplying them shall include branch-circuit overcurrent (short-circuit) protection as required for compliance with the *National Electrical Code.*

For a branch circuit without power conversion, overcurrent protection shall be placed in each ungrounded conductor.

Where a circuit breaker is used on the alternating-current input to the branch circuit, it shall open all ungrounded conductors of the circuit.

NEMA Standard 3-17-1976.

For a branch circuit with power conversion, the circuit is considered to include both input and output circuits of the conversion equipment whenever a definite correspondence exists between input and output currents. The circuit can then be protected by devices which are responsive to input or output currents or by a combination of devices.

Power conversion may include a transformer.

Authorized Engineering Information 3-17-1976.

The maximum rating or setting of motor power circuit protective devices shall be in accordance with the requirements of the *National Electrical Code.* Where static power conversion is used, the protective device current corresponding to the motor maximum continuous current shall be used as the basis for determining maximum ratings or settings.

NEMA Standard 3-17-1976.

The selection of ratings or settings of branch circuit short-circuit overcurrent devices should take into accound the exceptions to Table 430-152 provided in Section 430-52 of the *National Electrical Code* to assure that the ratings or settings are sufficient to allow for the starting current as well as the maximum expected running current of the motor.

Authorized Engineering Information 3-17-1976.

Overcurrent protective devices shall be located in the circuit at the point where the conductor to be protected receives its supply, except as follows:

EXCEPTION 1—Where the conductor: (a) has an ampacity of at least one-third that of the conductor from which it is supplied, (b) is suitably protected from physical damage, (c) is not over 25 feet long, and (d) terminates in a single circuit breaker or set of fuses.

EXCEPTION 2—Where the conductor: (a) has an ampacity not less than the sum of the maximum continuous load currents of all connected motors and apparatus supplied by that conductor that may be in operation at the same time, (b) is not over 10 feet long, and (c) does not extend beyond the control equipment enclosure.

.06 Several Motors on One Branch Circuit

Where two or more motors and their control equipment are connected to a single branch circuit, protection shall be provided in accordance with the *National Electrical Code,* Article 430, Part D.

NEMA Standard 3-17-1976.

.07 Overspeed Protection for Direct-current Motors

Unless the inherent characteristics of the motor and/or controller are such as to adequately limit the speed, controllers for direct-current motors shall include protection from overspeed so that personnel are not endangered by motor overspeed.

Suggested Standard for Future Design 3-17-1976.

Overspeed protection means include, but are not necessarily limited to, the following:

(a) A mechanical overspeed device incorporated in the drive to remove armature voltage on motor overspeed.
(b) An electrical overspeed detector which will remove armature voltage on motor overspeed.
(c) Field loss detection to remove armature voltage upon the loss of field current.
(d) Voltage-limiting speed regulated drives that operate with constant full field. In this case, protection is obtained individually for the loss of field or tachometer feedback; however, protection against simultaneous loss of field and tachometer is not provided.

The safe operating speed of the driven equipment may be less than that of the motor. In this case, the user should coordinate with the drive manufacturer to obtain the most suitable means of limiting operation to safe operating speed. Reference should also be made to par. ICS 3.1-4.05.02.e.

Authorized Engineering Information 3-17-1976.

.08 Power Transformer

A transformer used exclusively for one or more drive systems shall be protected against overload by at least one of the following:

(a) Primary or secondary overcurrent device(s) rated or set for not more than 125 percent of the transformer rated current.
(b) Protection responsive to transformer temperture.
(c) Device(s) used for motor running overload protection, providing the device(s) will protect the transformer from sustained load in excess of 125 percent of the transformer rated current.

.09 Draining of Stored Charge

Capacitors shall be provided with a means of draining the stored charge.

(a) *Time of Discharge*—The residual voltage of a capacitor shall be reduced to 50 volts or less within 1 minute after the capacitor is disconnected from the source of supply.

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(b) *Means of Discharge*—The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank upon the removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

When the time required for draining stored charges to 50 volts is more than 5 seconds, a warning shall be provided.

NEMA Standard 3-17-1976.

.10 Short-circuit Withstandability of Equipment

Under normal operating conditions, control equipment shall not create an electrical hazard to operating personnel in the event of a short circuit at any point within the control equipment when it is connected to the power supply specified on the nameplate.

Suggested Standard for Future Design 3-17-1976.

ICS 3.1-2.05 CONTROL CIRCUITS

.01 Source of Control Power

The control circuit shall be connected to a power source on the load side of the main disconnect device, or a separate disconnect device shall be provided for the control power adjacent to the main disconnect device.

NEMA Standard 3-17-1976.

.02 Control Voltage

Control circuits connected to manually operated devices shall be isolated from alternating-current voltages above 150 volts and from direct-current voltages above 300 volts.

Suggested Standard for Future Design 3-17-1976.

.03 Connection of Control Devices

All operating coils of alternating-current control devices shall be connected to the same side of the control circuit, and provision shall be made for grounding that side of the line at the control circuit transformer.

NEMA Standard 3-17-1976.

All contacts should be connected to the other side of the line except as follows:

(a) Overload relay contacts may be connected in the line having provision for grounding if the conductors between such contacts and the coils of magnetic devices do not extend beyond the control enclosure.
(b) Where relay and electronic circuits are mixed, control contacts in the electronic circuit may be connected as required.
(c) Where a contact(s) on the ungrounded side of the coil(s) would require the addition of a sliding contact collector to complete the circuit. Contacts may be connected in the line having provision for grounding.

Authorized Engineering Information 3-17-1976.

.04 Interlocking

(a) *Opposing Motions Interlocked*—All reversing starters, contactors controlling mechanically connected solenoids, and contactors controlling opposing motions, shall be protected from simultaneous energization.
(b) *Plugging Circuits*—All plugging switches or zero speed switches that are used to control the application or removal of power in order that moving parts may be slowed down, stopped, or reversed shall be provided with features incorporated in the control circuit to prevent the reapplication of power after the completion of the plugging operation and to prevent the application of power through any manual movement of the plugging switch shaft, or of the motor or equipment.
(c) *"Stop" by Deenergization*—Any operating device for initiating a manual stop function shall be normally closed and shall operate when its pilot circuit is opened.

NEMA Standard 3-17-1976.

ICS 3.1-2.06 CONTROL DEVICES

.01 Alternating-current Motor Starters

When operated, alternating-current motor starters shall open all of the power conductor leading to their associated motors.

.02 Contactors

Where a definite-purpose contactor is used in conjunction with gate interlocking, the contactor shall be capable of interrupting current up to the maximum current limit setting at maximum voltage at least once, independent of the gate interlocking. Where gate interlocking is not provided, contactors shall meet the requirements of the NEMA Publication Nos. ICS 1 through ICS 6.

NEMA Standard 3-17-1976.

ICS 3.1-2.07 CONTROL ENCLOSURES

.01 Materials

All enclosures shall be made of materials that will not support combustion in air.

.02 Doors

Doors shall swing a minimum of 90 degrees. All parts of door fasteners shall remain captive when the door is opened.

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The outer door assembly shall accommodate locking means or shall require the use of a tool to open except when it is specified for use where access is limited to qualified persons.

NEMA Standard 3-17-1976.

.03 Wall Thickness

The walls of enclosures shall be not less than the following:

(a) *Sheet Metal*—Not less than indicated in Tables 6-110-10 or 6-110-11 in NEMA Publication No. ICS 6 (reprinted on pages 8 and 9).
(b) *Cast Metal*—Not less than 1/8 inch.
(c) *Malleable Iron*—Not less than 3/32 inch.

Suggested Standard for Future Design 3-17-1976.

.04 Size of Opening

(a) *Nonventilated Enclosures*—General-purpose nonventilated enclosures shall prevent the entrance of a rod having a diameter of 0.125 inch except that, if the distance between the opening and the nearest live parts is greater than 4 inches, the opening may permit the entry of a rod having a diameter greater than 0.125 inch but not greater than 0.500 inch.
(b) *Ventilated Enclosures*—General-purpose ventilated enclosures shall prevent the entrance of a rod having a diameter of 0.500 inch except that, if the distance between the opening and the nearest live parts is greater than 4 inches, the opening may permit the entry of a rod having a diameter greater than 0.500 inch but not greater than 0.750 inch.

.05 Minimum Wire Size

When openings are screened, the wire gage of the screen shall be not less than No. 16 AWG (American Wire Gage). When the screen mesh openings are greater than 1/2 square inch (3.22 cm^2) in area, the wire gage shall be not less than No. 12 AWG.

.06 Screen Enclosures

All enclosures composed of wire mesh, perforated screens, or grillwork shall be provided with a supporting frame.

NEMA Standard 3-17-1976.

ICS 3.1-2.08 CONDUCTORS

.01 General

The internal wiring shall consist of material which is suitable for the particular application with respect to temperature, voltage and condition of service.

.02 Size

Conductors for panel wiring shall be no smaller than No. 18 AWG and those for electronic and solid state control subassemblies no smaller than No. 30 AWG. Conductors for control circuits shall be of annealed copper.

.03 Ampacity

The maximum continuous current of panel wiring conductors in control equipment shall not exceed the ampacity given in Table 2-1.

For single-motor drives, the motor power circuit conductors shall have an ampacity not less than the maximum continuous rms current rating of the motor. For multimotor drives, the motor power circuit conductors shall have an ampacity not less than the maximum continuous rms current rating of the highest rated motor, plus the sum of the maximum continuous rms current ratings of all other connected motors and apparatus that may be in operation at the same time.

NEMA Standard 3-17-1976.

For direct-current motor drives, the rms current may be estimated from the average current rating appearing on the motor nameplate and the rated form factor, if stated, or the characteristics of the identified power supply.

Authorized Engineering Information 3-17-1976.

ICS 3.1-2.09 WIRING METHODS AND PRACTICES

.01 Identification

Terminals on terminal blocks for connection to wires outside of the control equipment shall be marked to correspond with the markings on the diagrams.

Where white is used to identify wire at any incoming or outgoing terminal of a control equipment, it shall be used only for terminals which can be connected to a grounded conductor. Where green (or green with one or more yellow stripes) is used to identify wire at any incoming or outgoing terminal of a control equipment, it shall be used only for an equipment grounding or bonding conductor.

EXCEPTION—White and green shall be permitted for internal wiring if outgoing connections are permanently identified as other than ground connections and are not used as incoming power connections.

NEMA Standard 3-17-1976.

Where color coding is used, only the terminations of the conductor need be identified.

Authorized Engineering Information 3-17-1976.

.02 Terminals

User terminals, if provided, shall be selected on the basis of the 75°C temperature rating of conductors given in Table 310-16 of the *National Electrical Code.*

Terminals for power circuits shall be grouped separately from control circuits.

NEMA Standard 3-17-1976.

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Table 6-110-10‡
THICKNESS OF CARBON OR STAINLESS-STEEL SHEET-METAL ENCLOSURES

Maximum Dimensions of Any Surface				
Without Supporting Frame*		With Supporting Frame or Equivalent Reinforcing*		Minimum Thickness of Sheet, Inches
Maximum Width, Inches†	Maximum Length, Inches	Maximum Width, Inches†	Maximum Length, Inches	
4.0	Not Limited	6.25	Not Limited	0.020
4.75	5.75	6.75	8.25	0.020
6.0	Not Limited	9.5	Not Limited	0.026
7.0	8.75	10.0	12.5	0.026
8.0	Not Limited	12.0	Not Limited	0.032
9.0	11.5	13.0	16.0	0.032
12.5	Not Limited	19.5	Not Limited	0.042
14.0	18.0	21.0	25.0	0.042
18.0	Not Limited	27.0	Not Limited	0.053
20.0	25.0	29.0	36.0	0.053
22.0	Not Limited	33.0	Not Limited	0.060
25.0	31.0	35.0	43.0	0.060
25.0	Not Limited	39.0	Not Limited	0.067
29.0	36.0	41.0	51.0	0.067
33.0	Not Limited	51.0	Not Limited	0.080
38.0	47.0	54.0	66.0	0.080
42.0	Not Limited	64.0	Not Limited	0.093
47.0	59.0	68.0	84.0	0.093
52.0	Not Limited	80.0	Not Limited	0.108
60.0	74.0	84.0	103.0	0.108
63.0	Not Limited	97.0	Not Limited	0.123
73.0	90.0	103.0	127.0	0.123

* A supporting frame is a structure of 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 which may be 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. Construction 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, stiffening member or reinforcing by forming so as to prevent or minimize the deflection of the sheet metal. Adjacent surfaces may have supports in common and be made of a single sheet.

Suggested Standard for Future Design 3-17-1976.

‡Quoted from NEMA Standards Publication No. ICS 6

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Table 6-110-11‡
THICKNESS OF ALUMINUM, COPPER OR BRASS SHEET-METAL ENCLOSURES

Maximum Dimensions of Any Surface				
Without Supporting Frame*		With Supporting Frame or Equivalent Reinforcing*		Miminum Thickness of Sheet, Inches
Maximum Width, Inches†	Maximum Length, Inches	Maximum Width, Inches†	Maximum Length, Inches	
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	123.0	Not Limited	0.153
60.0	74.0	130.0	160.0	0.153

* A supporting frame is a structure of 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 ridigity to resist the bending moments which may be 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. Construction considered to be "without supporting frame" include:

(a) A single sheet with single formed franges (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, stiffening member or reinforcing by forming so as to prevent or minimize the deflection of the sheet metal. Adjacent surfaces may have supports in common and be made of a single sheet.

Suggested Standard for Future Design 3-17-1976.

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Table 2-1
AMPACITIES OF COPPER CONDUCTORS WITH AN INSULATION RATING OF 90°C AT AN AMBIENT TEMPERATURE OF 55°C

Conductor Size, AWG	Ampacity	Conductor Size, AWG or MCM	Ampacity
30	0.5	2/0	225
28	0.8	3/0	260
26	1	4/0	300
24	2	250	340
22	3	300	375
20	5	350	420
18	7	400	455
16	10	500	515
14	20	600	575
12	25	700	630
10	40	750	655
8	55	800	680
6	80	900	730
4	105	1000	780
3	120	...	...
2	140	...	...
1	165	...	...
1/0	195	...	...

NOTE I—The ampacities of insulated copper conductors with insulation ratings of 110°, 125° and 200°C can be considered as being 125, 140 and 170 percent, respectively, of the ampacities given in the above table for the same conductor size.

NOTE II—The ampacities of aluminum conductors with an insulation rating of 90°C can be obtained by multiplying the ampacity given in the table for the same size of copper conductors by 0.78.

The ampacities of insulated aluminum conductors with insulation ratings of 110°, 125° and 200°C can be considered as being 116, 124 and 134 percent, respectively, of the ampacities calculated for the same size of aluminum conductor with an insulation rating of 90°C.

NOTE III—The ampacities listed in the table and determined in accordance with Notes I and II apply to wireways or bundles greater than 5 feet in length. They include an allowance: (1) for wireways for conductor sizes 12 AWG and smaller, and (2) for bundles of one through six conductors larger than 12 AWG.

NOTE IV—Ampacities for conditions other than those covered in the table will differ and can be determined by interpolation or extrapolation. For example, for conductors having an insulation rating of 90°C, the ampacities at an ambient temperature of 40°C will be 120 percent of those at 55°C.

NOTE V—The ampacities given in the table can be exceeded if the routing and operating conditions of the conductor are known and controlled so as to limit the conductor temperature to the rated temperature of the insulation.

.03 Panel Wiring

The surface of wiring channels, if used, shall be of a flame-retardant material.

Suggested Standard for Future Design 3-17-1976.

Wiring routings shall avoid sharp edges, burrs, moving parts, etc., which may cause abrasion of the insulation and conductors. Holes in walls or barriers through which insulated wires pass and on the edges of which they may bear shall be provided with smoothly rounded bushings or grommets or shall have smooth, well-rounded surfaces upon which the wires may bear, to prevent abrasion of the insulation.

Wireways shall be smooth and entirely free from burrs.

.04 Spacings

The clearance and creepage distance between nonarcing uninsulated live parts, and

(a) Nonarcing uninsulated parts of different potential.
(b) Metal parts (other than enclosure walls) which may be grounded when the equipment is installed,
(c) Exposed ungrounded metal parts, and
(d) The walls of a metal enclosure (including fittings for conduit or armored cable)

shall be not less than those shown in Tables 1-111-1 or 1-111-2 of NEMA Publication No. ICS 1 (reprinted on pages 11 through 13).

NEMA Standard 3-17-1976.

Table 1-111-1 of NEMA Standards Publication No. ICS 1 applies for general use on all power systems where the transient voltages are not controlled or known. Table 1-111-2 of NEMA Standards Publication No. ICS 1 applies where provision is made to limit random surge and transient peak voltages to a total of not more than 300 percent of the instantaneous peak working voltage or 300 volts, whichever is greater. This limitation on surge and transient peak voltages applies between uninsulated live parts or between uninsulated live parts and ground when the apparatus is subjected to the 1.2/50 impulse test specified in Part ICS 1-109.22 of NEMA Standards Publication No. ICS 1.

Suggested Standard for Future Design 7-12-1978.

EXCEPTION 1—The clearances and creepage distances given in Tables 1-111-1 and 1-111-2 of NEMA Standards Publication No. ICS 1 do not apply to internal parts of hermetically sealed or encapsulated components; however, the external connections on such components shall have the clearance and creepage distances specified in this publication, unless the components are in accordance with the NEMA standards for these components and those standards cover industrial applications.

EXCEPTION 2—Table 1-111-2 of NEMA Standards Publication No. ICS 1 spacings are not required when surge suppression means are used to limit random surge and transient peak voltages to not more than 300 volts peak and meet the test require-

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Table 1-111-1‡
CLEARANCE AND CREEPAGE DISTANCES FOR GENERAL USE
WHERE TRANSIENT VOLTAGES ARE NOT CONTROLLED OR KNOWN

Group	Voltage Rating, Volts (Rms or Direct-current) (See Notes 2 & 3)	Minimum Clearance and Creepage Distance, Inches					
		To Other Than Enclosure Walls				To Walls of Metal Enclosure (See Notes 4 & 5)	
		Clearance Through Air (See Note 1)	Clearance Through Oil (See Note 1)	Creepage Along Surface Air	Creepage Along Surface Oil	Clearance Through Air or Oil	Creepage Along Surface
A. General industrial control.	0–50	0.125	0.125	0.125	0.125	0.500	0.500
	51–150	0.125	0.125	0.250	0.250	0.500	0.500
	151–300	0.250	0.250	0.375	0.375	0.500	0.500
	301–600	0.375	0.375	0.500	0.500	0.500	0.500
	601–1000	0.550	0.450	0.850	0.625	0.800	1.000
	1001–1500	0.700	0.600	1.200	0.700	1.200	1.650
	1501–2500*	1.000	0.750	2.000	1.000	2.000	3.000
	2501–5000*	2.000	1.500	3.500	2.000	3.000	4.000
B. Industrial control with per pole and total load restrictions. See Note 6.	51–300	0.063	0.063	0.125	0.125	0.250	0.250
	301–600	**0.188**	**0.188**	**0.375**	**0.375**	**0.500**	**0.500**
C. Industrial control with per pole restrictions. See Note 7.†	51–150	0.125	0.125	0.250	0.250	0.250	0.250
	151–300	0.250	0.250	0.250	0.250	0.250	0.250

† Group D deleted 9-20-1978.

* Because of the effect of configurations of metal parts, spacings in excess of those listed for these ratings may be required to meet the requirements of the impulse voltage tests described in Part ICS 2-324 of NEMA Standards Publication No. ICS 2.

NOTE 1—The spacing between screw-type wiring terminals of opposite polarity shall be not less than 0.250 inch if the terminals are in the same plane.

NOTE 2—Where the repetitive peak voltage on which the device is used is more than 1.5 times the rms volts, the peak voltage shall be divided by $\sqrt{2}$ to obtain an equivalent rms rating in volts.

NOTE 3—For grounded power systems, such as three-phase four-wire systems, the clearance and creepage distances to ground shall be governed by the voltage to ground.

NOTE 4—For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce clearance and creepage distances between the metal piece and uninsulated live parts.

NOTE 5—For subassembly enclosures where clearance and creepage distances are rigidly maintained and when mounted inside another enclosure, the distances for "to other than enclosure walls" may be used instead of "to walls of metal enclosure" but in no case shall they be less than 0.100 inch.

NOTE 6—The maximum per pole ratings are limited to 1 HP or less; 720 VA or less; 15 A at 51-150 V; 10 A at 151-300 V; 5 A at 301-600 V. For multipole devices, intended to control more than one load, the total load controlled at one time is limited to two times these values.

NOTE 7—The maximum per pole rating is limited to 1 HP or less; 2000 VA or less: 15 A at 51-150 V; 10 A at 151-300 V.

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Table 1-111-2‡
CLEARANCE AND CREEPAGE DISTANCES FOR USE WHERE TRANSIENT VOLTAGES ARE CONTROLLED AND KNOWN

Group	Instantaneous Peak Working Voltage, Volts (See Note 3)	Minimum Clearance and Creepage Distance, Inches			
		To Other than Enclosure Walls (See Note 6)		To Walls of Metal Enclosure (See Notes 4 and 5)	
		Clearance Through Air (See Note 1)	Creepage Along Surface In Air	Clearance Through Air	Creepage Along Surface
E. For general use where transient voltages are known and controlled by the apparatus or by specified external means.	0–50	0.030	0.030	0.500†	0.250
	51–225	0.075	0.100	0.500	0.500
	226–450	0.150	0.200	0.500	0.500
	451–900	0.300	0.400	0.500	0 500
	901–1400	0.438	0.625	0.750	1.0
	1401–2100	0.625	1.0	1.0	1.5
	2100–3500	1.0	1.6	2.0	3.0
	3501–7000	2.0	3.5	3.0	4.0
F. For use where transient voltages are known and controlled by the apparatus or by specified external means and the power supplying the circuit under consideration is limited to a short circuit of 10 kilovolt-amperes or less. (See Notes 2 & 7.)	0–30	0.030	0.030*	0.500†	0.250
	31–50	0.030	0.030	0.500†	0.250
	51–225	0.060	0.060	0.500	0.500
	226–450	0.100	0.100	0.500	0.500
	451–900	0.200	0.200	0.500	0.500
	901–1400	0.300	0.300	0.500	0.750
	1401–2100	0.450	0.450	0.500	1.0
G. For use where transient voltages are known and controlled by the apparatus or by specified external means and the power supplying the circuit under consideration is limited to a short circuit of 500 volt-amperes or less. (See Notes 2 and 7.)	0–36	0.012	0.012‡	0.500†	0.250
	37–72	0.016	0.016‡	0.500†	0.250
	73–100	0.030	0.030‡	0.500†	0.250
	101–225	0.045	0.045	0.500	0.500
	226–450	0.060	0.060	0.500	0.500
	451–900	0.100	0.100	0.500	0.500

* Smaller creepage distances are permissible for this voltage range if the live parts of different potential are rigidly attached to an insulating surface and provided suitable precautions are applied for environmental protection.

† Where deflection of the enclosure wall cannot reduce the through-air spacing to the enclosure wall, the spacing through air may be 0.250 inch.

‡ Pollution shall be taken into account through the use of larger dimensions, protective coating or enclosures, mounting orientation, preventive maintenance, or by other acceptable means. Pollution is any material or condition which supplies conductive particles and/or ions to an electric field, changing the normal condition of the electric field at rated temperature, atmospheric pressure and relative humidity.

NOTE 1—The spacing between screw-type wiring terminals of opposite polarity shall be not less than 0.250 inch if the terminals are in the same plane.

(Continued)

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Table 1-111-2‡*(Cont.)*
CLEARANCE AND CREEPAGE DISTANCES FOR USE WHERE TRANSIENT VOLTAGES ARE CONTROLLED AND KNOWN

NOTE 2—Maximum short-circuit voltamperes is determined as the product of the open-circuit voltage and the short-circuit amperes available at the supply terminals when protective devices are by-passed.

NOTE 3—For grounded power systems, such as three-phase four-wire systems, the clearance and creepage distances to ground shall be governed by the voltage to ground.

NOTE 4—For the purpose of this requirement, a metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce clearance and creepage distances between the metal piece and uninsulated live parts.

NOTE 5—For subassembly enclosures where clearance and creepage distances are rigidly maintained and when mounted inside another enclosure, the distances for "to other than enclosure walls" may be used instead of "to walls of metal enclosure" but in no case shall they be less than 0.100 inch.

NOTE 6—The clearance and creepage distances of 0.100 inch and less are particuarly intended for use on printed circuit boards or small devices where the distances are precision controlled. They shall not be used on main power circuits, such as bus or contactors. See Part ICS 1-113 for material.

NOTE 7—Spacings in signal or control circuits originating from main power circuits shall be in accordance with Group A or E up to the point where circuit conditions permit the use of spacings in accordance with Group F or G. Products designed in accordance with Groups F and G spacings include a supply which limits the short-circuit VA to values shown.

‡Quoted from NEMA Standards Publication No. ICS 1.

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ments of ICS 1-109.22 of NEMA Standards Publication No. ICS 1. However, provision shall be made to preserve the integrity of the spacings throughout the service life of the equipment through the use of suitable means of protection from pollution and mechanical forces which could bridge clearances or cause leakage currents across creepage distances and the use of materials which will not deteriorate with age, moisture or leakage current. In addition, external connections shall comply with the minimum spacing requirements of Table 1-111-2 of NEMA Standards Publication No. ICS 1.

EXCEPTION 3—The clearance and creepage distances given in Tables 1-111-1 and 1-111-2 of NEMA Standards Publication No. ICS 1 do not apply to snap switches, lampholders, and similar wiring devices used as part of industrial control equipment, provided such devices are not employed in motor circuits.

EXCEPTION 4—This standard does not apply to the internal spacings of rotating electric machines, or to motor control center bus spacings, or to the open gaps of contacts. NEMA Standard 7-12-1978.

Clearance and creepage distances shall be measured for various situations involving ridges or grooves between conductive parts as shown on Figures 1-111-1 through 1-111-12 of NEMA Publication No. ICS 1 (reprinted on pages 15 and 16).

NEMA Standard 7-12-1978.

It is anticipated that, when work being done for the development of IEC standards on spacings is completed, the NEMA requirements will be reviewed and, if necessary, changed in order to achieve harmonization.

Authorized Engineering Information 7-12-1978.

ICS 3.1-2.10 GROUNDED CIRCUITS AND EQUIPMENT GROUNDING

.01 Enclosure Lighting Circuits and Convenience Outlets

When the equipment includes lights or convenience outlets supplied by a transformer that is part of the equipment, one side of the circuit shall be grounded at the transformer by bonding it to the equipment enclosure or framework.

The grounded conductors shall be identified by a white or natural gray colored insulation.

The grounded conductor, when run to a screw-shell lampholder, shall be connected to the screw shell.

(a) *Convenience Plugs and Receptacles*

(1) Convenience plugs and receptacles shall be provided with a grounding pole and shall be so constructed that the grounding pole is made before any current-carrying poles are made and is not broken until all current-carrying poles of the plug have been disconnected.

(2) The grounding pole of both plugs and receptacles shall be used for grounding purposes only and not as a formal current-carrying pole.

(b) *Work Lights*

(1) The lighting circuit voltage shall not exceed 150 volts between conductors.

(2) The work light circuit shall be arranged so as to be energized by one of the following methods when the equipment is otherwise totally deenergized:

(i) Light circuits shall be wired so that they may be supplied from a separately protected branch circuit.

(ii) Where the equipment includes the disconnecting means, the light circuit shall be tapped off the line side of the disconnecting means, provided a disconnecting means for the light circuit is mounted adjacent to the main disconnecting means. There shall be no exposed live parts in the light circuit.

EXCEPTION—When specified and when separate overcurrent protection for the light circuit is provided, the light circuit shall be tapped off the load side of the disconnecting means or shall be tapped off the control circuit.

(3) The conductors to stationary or built-in lights shall meet the requirements of ICS 3.1-2.08. The conductors within fixtures shall be not smaller than 18 AWG.

.02 Methods of Grounding

Exposed noncurrent-carrying metal parts shall be electrically bonded to the enclosure or to a ground bus or ground terminal. Moving enclosure parts which have metal-to-metal bearing surfaces shall be considered as being adequately bonded. Sliding parts separated by oil or air under pressure shall not be considered to be bonded together.

Portable, pendent and resilient mounted equipment shall be bonded or provided with grounding screws to allow bonding.

.03 Equipment Grounding Conductors

Grounding conductors shall be in accordance with the *National Electrical Code,* Article 250, Part J.

NEMA Standard 3-17-1976.

ICS 3.1-2.11 SETUP AND SERVICE REQUIREMENTS FOR ENERGIZED EQUIPMENT

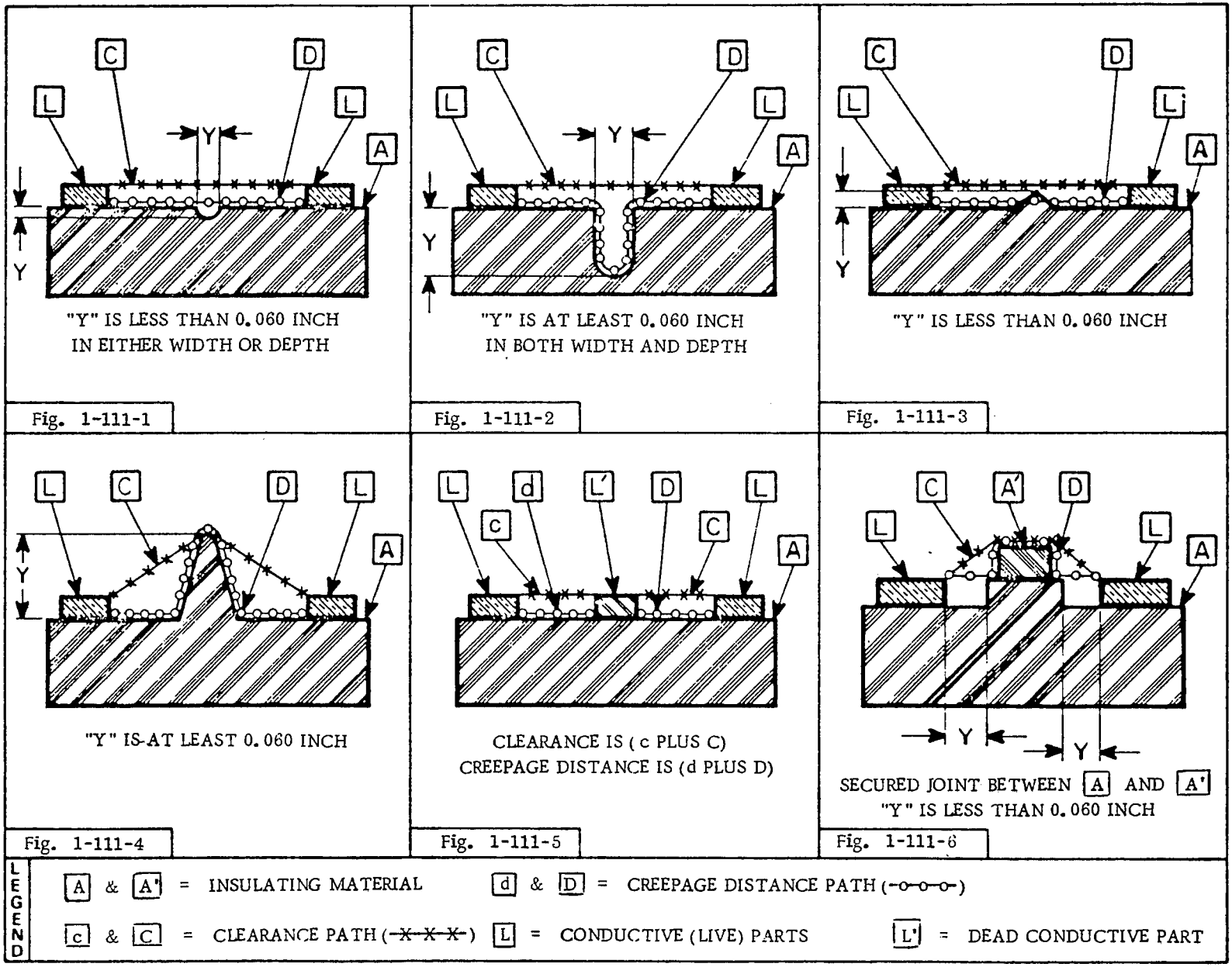
.01 Movable Assemblies

If a portion of the equipment carries more than 50 volts and can be moved into a position outside of the volume occupied by the closed enclosure or

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Figs. 1-111-1 through 1-111-12‡
MEASUREMENT OF SPACINGS



0.060" = 1.52 mm

(*Continued*)

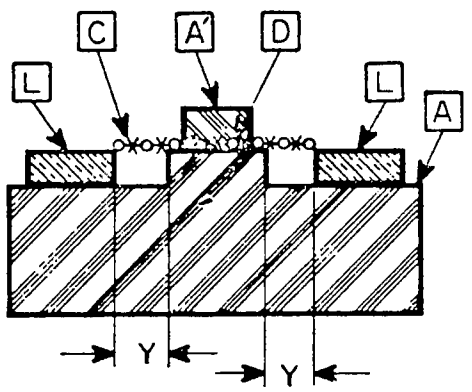
‡Quoted from NEMA Standards Publication No. ICS 1.

ICS 3.1-83
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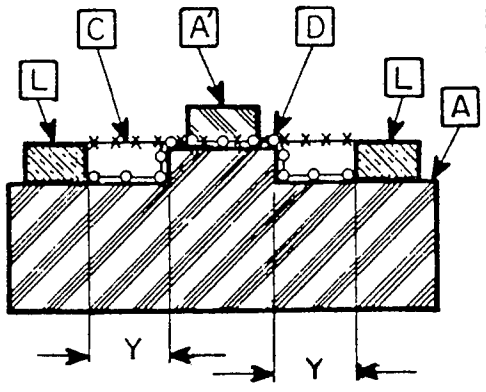
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Figs. 1-111-1 through 1-111-12 *(Cont.)*‡
MEASUREMENT OF SPACINGS



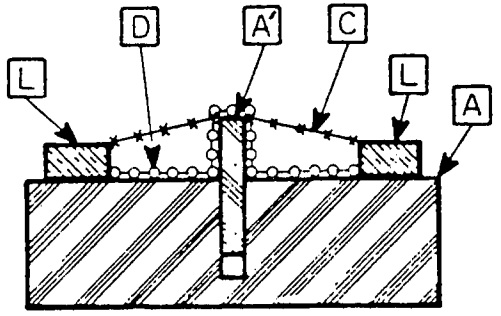
UNSECURED JOINT BETWEEN [A] AND [A'] "Y" IS LESS THAN 0.060 INCH

Fig. 1-111-7



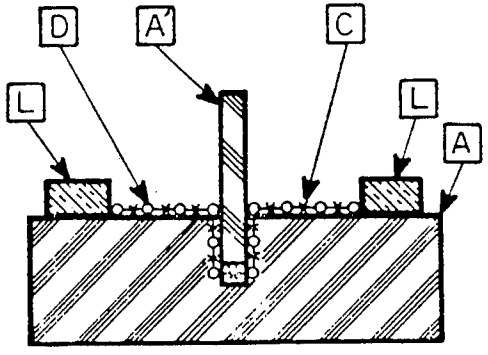
UNSECURED JOINT BETWEEN [A] AND [A'] "Y" IS AT LEAST 0.060 INCH

Fig. 1-111-8



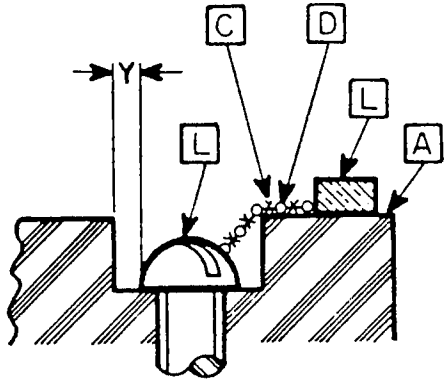
BARRIER [A'] INSERTED AND UNSECURED WHEN CLEARANCE PATH OVER THE BARRIER IS LESS THAN PATH UNDER THE BARRIER

Fig. 1-111-9



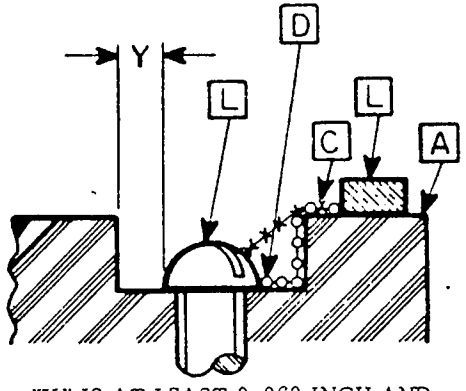
BARRIER [A'] INSERTED AND UNSECURED WHEN CLEARANCE PATH UNDER THE BARRIER IS LESS THAN PATH OVER THE BARRIER

Fig. 1-111-10



"Y" IS LESS THAN 0.060 INCH AND UNIFORM AROUND THE SCREW HEAD

Fig. 1-111-11



"Y" IS AT LEAST 0.060 INCH AND UNIFORM AROUND THE SCREW HEAD

Fig. 1-111-12

LEGEND

[A] & [A'] = INSULATING MATERIAL [d] & [D] = CREEPAGE DISTANCE PATH (-o-o-o-)

[c] & [C] = CLEARANCE PATH (-x-x-x-) [L] = CONDUCTIVE (LIVE) PARTS [L'] = DEAD CONDUCTIVE PART

0.060" = 1.52 mm

‡Quoted from NEMA Standards Publication No. ICS 1.

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into an aisle, the assembly shall include guarding for circuits above 50 volts except where the short-circuit current for these voltages is limited to less than 5 milliamperes.

.02 Adjustments, Monitoring Points and Manual Operators

Adjustments, monitoring points and manual operators which are normally used with the equipment energized shall be accessible from the front of the equipment and, except where the short-circuit current is limited to less than 5 milliamperes, shall not require personnel or tools to come closer to adjacent exposed parts energized at more than 50 volts than the surface of a hemisphere 6 inches in diameter plus a truncated 45-degree cone whose diameter is 6 inches at the point of adjustment and whose axis is parallel to the direction of access. See Fig. 2-1.

Suggested Standard for Future Design 3-17-1976.

.03 Nonelectrical Apparatus

Nonelectrical apparatus shall not be located in the same compartment with electrical control equipment unless the devices and their air, water or hydraulic fluid supply lines are essential to the operation of the electrical components. Nonelectrical apparatus shall not require servicing while the electrical apparatus is energized.

NEMA Standard 3-17-1976.

.04 Unguarded Terminals

Except where the short-circuit current is limited to less than 5 mA, floor-mounted enclosed equipment shall have no unguarded live parts above 50 volts within the space 6 inches from the front and 24 inches above the floor.

Terminals of floor-mounted transformers which can be contacted accidentally shall be guarded.

Suggested Standard for Future Design 3-17-1976.

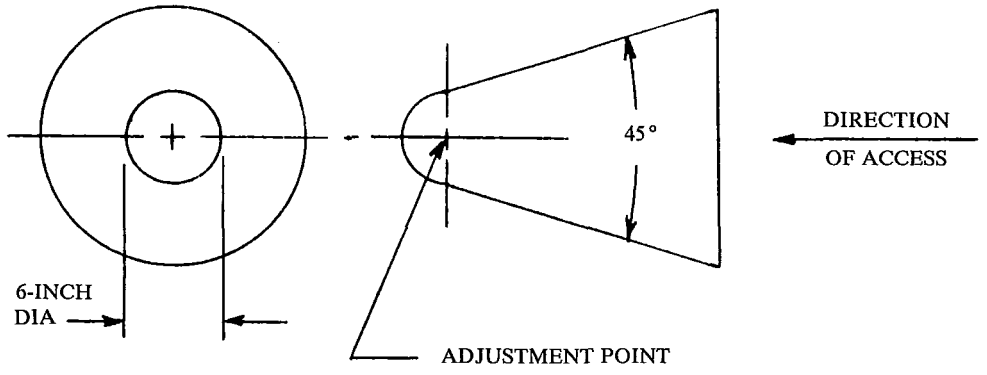


Fig. 2-1

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Part 3
HIGH-POTENTIAL TESTS

ICS 3.1-3.01 MOTORS AND GENERATORS

Motors and generators shall be capable of withstanding the high-potential tests described in par. MG 2-2.10 of NEMA Publication No. MG 2.

NEMA Standard 3-17-1976.

ICS 3.1-3.02 CONTROL EQUIPMENT AND SYSTEMS

Industrial control equipment and systems shall be capable of withstanding the high-potential tests described in Part ICS 1-109.21 of NEMA Publication No. ICS 1.

NEMA Standard 7-12-1978.

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Part 4
GUIDE FOR SAFETY IN SELECTION, INSTALLATION, AND OPERATION OF ADJUSTABLE-SPEED DRIVE SYSTEMS

SAFETY IN APPLICATION

ICS 3.1-4.01 FACTORS TO BE CONSIDERED

The applications for adjustable-speed drive systems are so numerous that exceptions can be cited to almost every recommendation for safe application. Among the many factors that must be considered in application are:

(a) Service conditions
(b) Degree of enclosure.
(c) Use of "back-up" equipment where the application requires exceptional reliability for the protection of life and health, property or perishable products.

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ICS 3.1-4.02 SERVICE CONDITIONS

Industrial motor controllers and drive systems should be properly selected with respect to their service conditions, usual or unusual, both of which involve the environmental conditions to which the machine is subjected and the operating conditions.

Service conditions, other than those specified as usual, may involve some degree of hazard. The additional hazard depends upon the degree of departure from usual operating conditions and the severity of the environment to which the equipment is exposed. The additional hazard results from such things as overheating, mechanical failure, abnormal deterioration of the insulation system, corrosion, fire and explosion.

Usual and unusual service conditions for motors are defined in pars. MG 2-3.07 and MG 2-3.08 of NEMA Publication No. MG 2.

Usual and unusual service conditions for industrial control and systems equipment are defined in Part 1-108 of NEMA Publication No. ICS 1. This information is also contained in American National Standard C19.3.

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ICS 3.1-4.03 DEGREE OF ENCLOSURE

.01 General

Recommendations for motor enclosures are given in Part 3 of NEMA Publication No. MG 2.

The required degree of enclosure for motor controllers and drive systems should be established by the user or the manufacturer of the driven equipment, considering the following:

(a) Will the equipment be installed in:
  (1) places regularly open to the public,
  (2) places frequented only by persons employed on the premises, or
  (3) places accessible only to qualified personnel?
(b) Will the equipment be attended by an operator when it is in use?
(c) Does the enclosure discourage inappropriate use or approaches to the equipment?
(d) Is it possible to encounter hazard in the installed equipment if it is approached or serviced in a manner other than the manner for which it was designed? If so, are the hazards of such actions visibly obvious to the personnel operating, servicing, and generally having access to the equipment?

The following recommendations for the selection of enclosures are given as a guide. In addition, it may be appropriate to make the equipment inaccessible by fencing, by isolation in a room, by additional enclosures, or by other means, so that access to the isolated areas is limited only to qualified personnel. Qualified personnel are those who are familiar with the construction and operation and maintenance of the equipment and the hazards involved.

.02 Application in Places Regularly Open to the Public

For those applications in places which are regularly open to the public and which cannot be isolated from the public, only the following equipment should be used:

(a) Motors as described in par. MG 2-3.04.B of NEMA Publication No. MG 2.
(b) Enclosed control and power conversion equipment with provision for locking or padlocking doors.

.03 Application in Places Restricted to Persons Employed on the Premises

Many years of experience in industrial plants, light commercial installations, and other areas where access to the equipment is normally restricted to persons employed on the premises have established that the following equipment has a successful and satisfactory safety record:

(a) Motors as described in par. MG 2-3.04.C of NEMA Publication No. MG 2.
(b) Enclosed control and power conversion equipment.

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.04 Application in Places Accessible Only to Qualified Personnel

Any of the enclosures mentioned in par. .03 may be used in these places. In addition, many years of experience in power plants and in other applications where equipment is so located or installed that it is accessible only to qualified personnel have established that open equipment has a successful and satisfactory safety record.

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ICS 3.1-4.04 MOTOR APPLICATION

Recommendations concerning the selection, operation and loading of motors are provided in par. MG 2-3.01 and par. MG 2-3.05 through MG 2-3.14 of NEMA Publication No. MG 2.

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ICS 3.1-4.05 CONTROL APPLICATION

.01 Incoming Line Equipment

For the protection of maintenance personnel, provisions may be needed for locking the disconnecting or isolation means in the open position. Locking requirements, such as lock size or number of locks to be used, should be specified. Disconnects should be specified in accordance with the type, rating and specific application of requirements given in paragraphs 430-101 through 430-113 of the *National Electrical Code.*

Certain types of drives such as alternating-current adjustable-voltage drives and drives with high harmonic content can have a maximum continuous current at reduced speed higher than the full-load current at rated speeds. For such applications, the maximum continuous current should be used as a basis for selection of equipment rating.

The required interruption capacity of incoming line equipment, particularly with respect to the available fault current of the supply to which the controller is to be connected, should be coordinated between manufacturer and user. Application information on ratings or protective settings of the protective devices is given in Table 430-152 and discussed in paragraphs 430-51 through 430-59 of the *National Electrical Code.*

.02 Control Safety Functions

(a) *Undervoltage*

(1) Undervoltage Protection—Undervoltage protection should be specified for all applications in which automatic or unexpected starting of a machine may be hazardous to persons or property.

Undervoltage protection requires that an operator initiate a reset or restart command each time the machine is to run following an unscheduled stop. If a power interruption occurs while the motor is running, the motor will stop and will not restart until the operator starts it after restoration of power.

Overload relays or other protective devices which can cause unscheduled stops should include provision for manual restarting in applications which require undervoltage protection. If the protective device resets automatically after a stop, it can be interlocked with the undervoltage protection to require a manual reset or restart command.

An intentional time delay is sometimes provided before the initiation of undervoltage protection. This allows the system to ride through a temporary loss of power without stopping. For applications which require an immediate stop, the sequence of protective functions should be so arranged that there is no intentional time delay.

(2) Undervoltage Release—Undervoltage release causes the drive to stop when power is interrupted but permits automatic restarting when power is restored. This type of control is commonly used for pumps, compressors, fans and similar applications controlled by float switches, thermostats, or time clocks.

Undervoltage release should not be used for applications in which automatic or unexpected starting of a machine may be hazardous to persons or property.

(b) *Interlocking*—Electrical and/or mechanical interlocking is frequently used to assure a desired sequence. The following are examples of types of interlocking which, when required should be specified for adjustable-speed drive systems:

(1) Limit switches to prevent overtravel of machine elements or interference with machine movements.

(2) Nonrepeat control interlocking. The cycle does not repeat if the start button is held in the closed position. It is necessary for the operator to release the start button and to push it again to start a new cycle.

(3) Door interlocks which prevent the opening of enclosure doors unless power is disconnected or which cause power to be disconnected if doors are opened.

(4) Interlocks to prevent the application of one polarity until the other polarity has been disconnected, in cases where such simultaneous application would present a hazard.

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(5) Interlocks to cause brakes to be set following a stop command.

(c) *Stop Functions*—A variety of stopping methods is available for every type of adjustable-speed drive. When experience has shown that a particular stopping method is satisfactory for use with a particular application, that method may be used. Otherwise, it is necessary to specify stopping performance in terms of time or distance and to provide information concerning inertia and speed-torque characteristics of the load.

The number and type of manual stop operator devices required should be specified. The types of devices commonly used for stopping are:

(1) Red button with flat or concave head for normal stops.

(2) Red mushroom head button for emergency stops.

(3) ON-OFF selector switch. (A RESET button is typically required when a selector switch is used with drives having undervoltage protection.)

Any specific requirements for stopping performance, such as may be required by certain industry standards, should be specified.

For emergency stops, reliability considerations may give preference to a particular stopping method. For example, a springset friction brake, properly maintained, is usually more reliable than a method that depends upon the availability of adequate electric power supply. For some applications, redundant stopping means may be necessary.

When there is more than one mode of system operation, the modes for which each operator device and protective function is to be effective should be specified.

(d) *Zero Speed Requirements*

(1) Stop Command—A stop (or off) command calls for the drive to come to a complete standstill and, typically, for the motor to be disconnected from the source of power to prevent any unscheduled movement.

Stopping is usually called for by the definite action of an operator such as operation of a pushbutton or selector switch, or by some switch or other relay contact. To restart the drive again requires a positive action such as operation of a pushbutton or sequencing contact. When stopped, the motor may be held from rotating by a mechanical brake if required by the application.

(2) Zero Speed Command—A zero speed command calls for the drive to provide regulation at zero speed with the motor remaining connected to the controller. This is normally accomplished by turning the speed setting potentiometer to zero or by having an output from some transducer or signal source go to zero. The drive is then ready to accelerate to any other speed upon the receipt of a change in the command signal.

The operator or maintenance personnel should not be exposed to the moving parts of the machine under a condition of zero speed command. When the operator may be exposed to the moving parts of the machinery, a stop or off command should be provided.

The maintaining of zero speed condition is dependent upon the drift or accuracy of the signal source as well as the characteristics of the drive controller. Where zero speed regulation is required by the application, this should be specified, and complete information concerning load characteristics and accuracy requirements should be furnished.

(e) *Speed Limitation*—Adjustable-speed drives should be prevented from operating at speeds which could cause injury to personnel or damage to the driving or driven machinery.

In many cases, the nature of the machines, the system or the load will inherently prevent excessive speed. When the machine is always under the manual control of a qualified operator, it may be satisfactory to depend upon the machine operator to safely limit the speed. In other cases, it is necessary for the purchaser to specify additional equipment, such as brakes, relays, or mechanical speed-limit devices, or to specify that the speed be held to selected limits, even in the event of specified malfunctions of the system.

Particular attention should be given to the following situations which may require speed-limiting devices:

(1) An overhauling load.

(2) Machine loading or adjustment requiring the speed to be held below the maximum rated speed of the drive equipment.

(3) A direct-current motor operating with weakened field excitation.

(4) A possible loss of load on a series-wound motor, or on motors connected in series, or on a motor controlled by a torque regulator.

Speed-limiting devices are seldom necessary for situations such as the following, in which the inherent characteristics of the motor tend to limit speed:

(5) When the motor drives a fan or other load for which the required torque increases greatly with speed.

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(6) When alternating-current motors operate from a fixed-frequency supply.

Section 430-89, Speed Limitation, in the *National Electrical Code* should be considered when determining the need for speed-limiting devices.

(f) *Equipment Protection*—Some functions designed to protect equipment from accidental damage also contribute to safety for personnel. Usual protective functions which apply to all systems include the following:

(1) Main and branch overcurrent protection.
(2) Control-circuit overcurrent protection.
(3) Undervoltage protection.
(4) Motor running overcurrent protection.
(5) Motor disconnecting means.

Additional protective functions which may contribute to the safety of personnel on a particular system should be specified. Such functions include:

(6) Field loss protection—shunt and compound-wound direct-current motors can be specified to have protection against loss of motor field.
(7) Motor overspeed protection.
(8) Current or torque limit.
(9) Voltage limit to prevent excessive armature voltage.
(10) Ground fault protection or indication.
(11) Instantaneous overload protection or indication.
(12) Friction brakes.
(13) Dynamic braking.
(14) Strip break detection.

(g) *Additional Control Safety Considerations*

The applications for adjustable-speed drive systems are so numerous that exceptions can be cited to almost every recommendation for safe application. Among the many factors that must be considered are:

(1) Overhauling Loads—Where the load is capable of delivering torque to the drive motor, as in hoists, the usual Form A (nonreversing, noninverting)* adjustable-speed drive may not be satisfactory.

*See ICS 3-104.08 in NEMA Publication No. ICS 3.

(2) High Inertia Loads—Where the reflected inertia of the load at the motor shaft is larger than the motor rotor inertia, additional consideration should be given to the rating and design of the drive, such as the selection of the dynamic braking resistors.

(3) Loss of Conductor—Where connections between the power source, controller and motor are made through sliding contacts, plug connectors or in any way in which continuity may be lost, resulting in loss of control of the motor, specific precautions may be necessary to prevent motor overspeed.

(4) Overtravel Protection—Where reversing or stopping of the drive is required at the end of travel, it may be desirable to provide back-up circuitry.

(5) Redundant Systems—The use of "back-up" equipment where the application requires exceptional reliability for the protection of life and health, property or perishable products may be necessary.

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SAFETY IN INSTALLATION

ICS 3.1-4.06 MOTORS

Recommendations concerning installation of motors are provided in par. MG 2-3.16 of NEMA Publication No. MG 2.

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ICS 3.1-4.07 CONTROL

.01 Lifting

When lifting or moving equipment, the manufacturer's recommendations should be followed.

.02 Location

The following considerations should be observed whenever equipment is mounted, installed or relocated.

(a) Motor control and power conversion equipment should be placed in locations appropriate for the type of construction and enclosure used.
(b) Equipment should be located in adequately ventilated areas. Ventilating openings should not be obstructed.
(c) Adequate working space should be provided for adjustment, inspection and maintenance.
(d) Operator's control stations should be convenient to permit observation of machine operation when this is necessary. The location should be such that the operator is free of hazard from moving parts of the machine or work in process and such that the control station is not subject to accidental operation or damage.

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(e) Operator's devices, such as emergency-stop pushbuttons, which are installed to provide safety, should be located so that they can be operated conveniently in the event that the condition for which they were selected occurs.

(f) Accessories such as limit switches should be located or protected so that they are accessible for inspection, adjustment, and maintenance and are not subject to accidental operation, damage, or contamination.

.03 Mounting

Control and power conversion apparatus should be securely fastened and/or supported in the manner recommended by the manufacturer.

The method of support should avoid excessive shock and vibration, using shock and vibration absorbent mountings if necessary to prevent damage to the equipment or connections to it. The manuufacturer's recommendations should be followed.

.04 Grounding

Equipment should be grounded in accordance with the *National Electrical Code.*

.05 Codes and Standards Requirements

Installation of controllers and drive systems should be made in conformance with the *National Electrical Code,* regulations of the Occupational Safety and Health Administration and/or other national, regional, or industry codes and standards.

.06 Lighting

Adequate lighting should be available for trouble-shooting and maintenance of the equipment.

.07 Flooring

A noncombustible insulating floor or mat should be provided in the area immediately surrounding the electrical system where maintenance is required.

.08 Locking Means

The main electrical disconnect should be easily accessible and have provisions for applying multiple padlocks. Each individual who performs maintenance on the drive system should be provided with a padlock for his use.

.09 Interconnecting Wiring

Where signal circuits such as those from speed-setting potentiometers and transducer outputs are located remote from the drive controller, the manufacturer's recommendations concerning the isolation and wiring of signal circuits should be followed.

.10 Installation Workmanship

A safe and reliable installation requires careful attention to the installation of conduit and other raceways, wire pullings, connections, etc., to avoid damage to conductor insulation and nicked wire terminations, and to assure continuity of the conduit and equipment enclosure grounding system. Unskilled workmen may be unaware of the requirements or hazards involved. It is recommended that only properly skilled workmen be employed for installing electrical equipment.

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ICS 3.1-4.07 START-UP AND TEST

Prior to releasing an electrical drive system for regular operation after installation, the system should be given a start-up test by competent personnel to assure correct operation of the equipment for reasons of reliable and safe performance. It is important that arrangements for such a check be made and that enough time is allowed to have it carried out well.

Such tests may be simple or complex, depending on the nature of the installation. A simple case may require only a check that a certain pushbutton starts an alternating-current motor, that the motor turns in the right direction, and that another push-button brings the motor to a stop. Other cases may involve the checking out of many devices and the proper operations of the overall system, including its regulators, logic functions and protective devices.

The variety involved precludes a detailed listing of checks. However, attention should be directed to the need of such start-up tests in order to detect and correct possible serious hazards for personnel and equipment.

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SAFETY IN OPERATION

ICS 3.1-4.08 GENERAL

Recommendations concerning the operation of motors are provided in par. MG 2-3.11 of NEMA Publication No. MG 2.

Regardless of the care exercised in the design and manufacture of an adjustable-speed drive or in the selection and rating of components, there are hazards which can be encountered if such equipment is improperly operated.

It is sometimes possible to misadjust the equipment and thus produce unsatisfactory or unsafe operation. The manufacturer's instructions should always be used as a guide for functional adjustments. Personnel who are to have access to these adjustments (setup and operating people) should be familiar with both the drive manufacturer's instructions and the machinery being driven.

Only those operational adjustments which are actually needed by the operator, as, for example, speed setting, tension adjusting means, etc., should be accessible to him. Access to other controls should be restricted to prevent unauthorized changes in operating characteristics.

Examples of improper (and perhaps unsafe) operation include:

(a) Setting the speed too high or too low for the specific application.
(b) Changing the cycle or sequence of the machine beyond those conditions for which the drive was originally designed.
(c) Changing the load being driven beyond the limits for which the equipment was intended.
(d) Substituting an improperly rated motor or other components.
(e) Attempting to bypass design functions, as, for example, attempting to jog at rates higher than the preset rate by using the start and stop function.

The operator of the drive equipment should be properly trained in the operation of the equipment. Provision of a written manual for use by supervisors in training new personnel should be considered.

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SAFETY IN MAINTENANCE

ICS 3.1-4.09 GENERAL

A well-planned and executed maintenance schedule is essential to the satisfactory operation of electrical equipment. The kind and frequency of the maintenance operation will vary with the kind and size of the equipment as well as with the nature of the operating conditions.

It is not possible to establish a single maintenance program to serve all classes of equipment within the scope of this publication. A maintenance program should be established giving due consideration to the operating and service conditions and the applications of the equipment as well as to the maintenance instructions and recommendations of the equipment manufacturer.

The following factors should be considered when formulating a maintenance program:

(a) Maintenance should be performed by qualified personnel.
(b) The equipment should be so located as to permit the performance of all maintenance operations without hazard to the worker.
(c) Whenever possible, maintenance should be performed with the equipment not in operation and disconnected from the line. In particular, the alternating-current primary power source for a direct-current motor used on an adjustable-voltage electronic power supply should be completely disconnected from the line.
(d) A general inspection of mechanical integrity, i.e., fracture, loose bolts, missing parts, etc., should be made.
(e) Vibration and noise should be observed. A change in the magnitude or frequency of the vibration and/or noise indicates a need for attention.
(f) Ventilation passages should be kept open. If the equipment depends upon auxiliary cooling, i.e., air, water, oil, etc., periodic inspection (with filter replacement when necessary) should be made of these systems.
(g) Periodic inspection and/or tests of the insulation system, when recommended by the manufacturer, should be made.
(h) Brushes, slip rings, and commutators should be frequently inspected and serviced as required.
(i) Lubrication procedures given in the machine manufacturers' instructions should be followed.
(j) The means employed for grounding or insulating the equipment from ground should be checked to assure its integrity.
(k) Flexible cords and connectors should be examined to determine that the cords are free from abrasion, cracks and exposed strands and that the connectors have unbroken bodies so that live parts are not exposed.
(l) If a breaker has tripped or a fuse has blown, a short circuit or ground may be indicated which may also have damaged the electrical

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equipment. The short circuit or ground should be located and removed. The contacts and/or overload relays in the controller should be replaced if necessary, and any other damage should be repaired before restoring power to the circuit.

(m) Accumulations of dust and dirt, including semiconductor heat sinks, should be cleaned out with a vacuum cleaner with an insulated nozzle or brush which has no exposed metal. Blowing out dust with a compressed air gun is not recommended. When cleaning equipment, the manufacturer's advice should be followed.

(n) Moving parts should be inspected to assure that they move freely without binding or sticking and are not badly worn. They should be replaced if necessary.

(o) Contacts should be inspected for excessive wear or burning and, if necessary, replaced in accordance with the manufacturer's instructions. Contact springs should be checked and replaced if the spring force no longer corresponds with the manufacturer's specification or if there is evidence of burning or overheating.

(p) Arc chambers and other insulating parts should be inspected and replaced if they are broken or badly eroded. Easily dislodged metal dust or granules, if any, should be removed. Insulating surfaces should not be scraped, sandpapered or filed.

(q) Terminals, fuse clips and connections should be inspected for evidence of loosening or overheating. If necessary, contact surfaces should be cleaned and loose connections tightened.

(r) Enclosures should be inspected for evidence of deterioration. Accumulated dust and dirt should be removed from the top of the enclosure before opening doors or removing covers.

(s) While not recommended, it may be necessary in an emergency to inspect or repair apparatus while it is energized. Safety goggles and insulating gloves should be worn. An insulating mat should be used if the floor is of metal, concrete, or other conducting material. Insulated tools having the least possible exposed metal should be used. Switches or contactors with their arc hoods removed should not be operated. Magnetic contactors should not be operated by hand. Only experienced personnel should do such work. Under no circumstances should work be done on equipment in Class I or Class II hazardous locations* while it is energized.

*See the *National Electrical Code.*

(t) After inspection, maintenance, or repair operations, steps should be taken to be sure that no hazard will occur to personnel, including maintenance personnel, before power is applied. All maintenance personnel should use individual padlocks to lock power supply disconnect devices in the open position while at work on the equipment.

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ICS 3.1-4.10 SAFETY RECOMMENDATIONS FOR MAINTENANCE PERSONNEL

(a) Individual padlocks and individual keys to assure that power is disconnected should be used when servicing the equipment.

(b) Rubber-soled shoes (without nails) are recommended when servicing electrical equipment.

(c) The practice of one hand in the pocket should be followed when servicing live equipment.

(d) When instruments such as oscilloscopes are used to work on live equipment, great caution must be used. When one of the instrument leads is connected to the case or other metal parts of the instrument, this lead should not be connected to an ungrounded part of the system unless the instrument is isolated from ground and its metal parts treated as live equipment.

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ICS 3.1-4.11 REPAIR

When equipment is repaired, it is important that any replacement part be in accordance with the recommendations of the equipment manufacturer. Care must be taken to avoid the use of parts which are no longer compatible with other changes in the equipment. Also, replacement parts should be inspected for deterioration due to "shelf life" and for signs of rework or wear which may involve factors critical to safety.

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Appendix A
REFERENCED STANDARDS

In this publication, reference is made, in part or in full, to the following standards listed below. Copies are available from the indicated sources.

I

American National Standards Institute
1430 Broadway
New York, NY 10018

C19.3-1973	*Industrial Control Apparatus—General*
ANSI/NFPA 70-84 (ANSI Pub. No. C1)	*National Electrical Code*

II

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

ICS 1-1983	*General Standards for Industrial Control and Systems*
ICS 2-1983	*Industrial Control Devices, Controllers and Assemblies*
ICS 3-1983	*Industrial Systems*
ICS 4-1983	*Terminal Blocks for Industrial Control Equipment and Systems*
ICS 5-1983	*Resistance Welding Control*
ICS 6-1983	*Enclosures for Industrial Controls and Systems*
MG 1-1978 (R 1981)	*Motors and Generators*
MG 2-1983	*Safety Standards for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators*

III

National Fire Protection Association
470 Atlantic Avenue
Boston, MA 02210

ANSI/NFPA 70-84 (ANSI Pub. No. C1)	*National Electrical Code*

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NEMA STANDARDIZATION

The purpose of NEMA Standards, their classification and status are set forth in certain clauses of the NEMA Bylaws, which are quoted 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.

(Bylaw—Art. V, Sec. 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.

(Bylaw—Art. V, Sec. 2, Subsection A)

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.

(NEMA Policy Memorandum 84-2, dated June 7, 1984)

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.

(Bylaw—Art. V, Sec. 2, Subsection B)

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.

(Bylaw—Art. V, Sec. 6, 1st Sentence)

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.

(Bylaw—Art. V, Sec. 4, Subsection A)

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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SYSTEMS GROUP
OF THE
INDUSTRIAL CONTROL AND SYSTEMS SECTION
OF THE
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

MEMBER COMPANIES

Allen-Bradley Company
Milkaukee, WI 53201

Automatic Switch Company
Florham Park, NJ 07932

Cleveland Machine Controls, Inc.
Cleveland, OH 44125

Eaton Corporation
Cutler-Hammer Products
Milwaukee, WI 53216

Cyberex, Inc.
Mentor, OH 44060

Electric Machinery
Industrial Controls Corporation
Macon, GA 31206

Emerson Electric Company
Grand Island, NY 14072

Furnas Electric Company
Batavia, IL 60510

General Electric Company
Salem, VA 24153

Harnischfeger Corporation
Milwaukee, WI 53201

Harvey Hubbell, Incorporated
Industrial Controls Division
Madision, OH 44057

Industrial Solid State Controls Inc.
York, PA 17405

Integrated Power Systems Corp.
Sugarland, TX 77478

Joslyn Clark Controls, Inc.
Lancaster, SC 29720

Klockner Moeller Corporation
Natick, MA 01760

McGill Manufacturing Company, Inc.
Valparaiso, IN 46383

Namco Controls Division
An Acme Cleveland Corporation
Mentor, OH 44060

Pertron Controls Corporation
Canoga Park, CA 91304

Reliance Electric Company
Athens, GA 30613-1299

Rise America, Inc.
Parlin, NJ 08859

Siemens-Allis, Inc.
Atlanta, GA 30356-9000

Square D Company
Milwaukee, WI 53201

Technitron, Inc.
Carol Stream, IL 60187

Telemecanique, Incorporated
Arlington Heights, IL 60005

Texas Instruments, Inc.
Attleboro, MA 02703

Toshiba International Corporation
Houston, TX 77041

Unico, Inc.
Franksville, WI 53126

Ward Leonard Electric Company, Inc.
Mt. Vernon, NY 10550

Weltronic Company
Subsidiary of Ransburgh Corporation
Novi, MI 48050

Westinghouse Electric Corporation
Buffalo, NY 14240

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