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NEMA ICS 2.3

INSTRUCTIONS FOR THE HANDLING, INSTALLATION, OPERATION, AND MAINTENANCE OF MOTOR CONTROL CENTERS RATED NOT MORE THAN 600 VOLTS

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

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NEMA Standards Publication ICS 2.3-1995

INSTRUCTIONS FOR THE HANDLING, INSTALLATION, OPERATION, AND MAINTENANCE OF MOTOR CONTROL CENTERS RATED NOT MORE THAN 600 VOLTS

Published by:

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Foreword

This publication is a guide to practical information containing instructions for the handling, installation, operation, and maintenance of motor control centers rated 600 volts or less. It is not the intent of these instructions to supersede the manufacturer's instructions. These instructions do not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise, which are not covered sufficiently, the matter should be referred to the manufacturer. These recommendations of the Industrial Control and Systems Section of the National Electrical Manufacturers Association will be found useful by architects, electrical engineers, electrical contractors, electricians, maintenance engineers, and others. They will be reviewed periodically by the Section for the purpose of updating them as necessary. Please address any comments or questions you may have on the text to:

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Section 1
GENERAL

1.1 SCOPE

These guidelines are provided to facilitate movement, handling, installation, and maintenance of motor control centers at the job site and to help avoid personal injury and equipment damage during these processes.

Information includes the following:

a. Handling

b. Storage

c. Installation of sections, units, conduits and wires

d. Pre-energization and energization

e. Permissible loading

f. Care and maintenance

1.2 There is a hazard of electric shock or burns to personnel whenever they are working on or near electrical equipment. Turn off power supplying this equipment before working inside motor control centers and lockout or tag out or both, disconnecting means in accordance with NFPA 70 E, Part II.* Where it is not feasible to de-energize the system, take the following precautions:

a. Persons working near exposed parts that are or may be energized should be instructed and should use practices (including appropriate apparel, equipment, and tools) in accordance with NFPA 70 E, Part II.

b. Persons working on exposed parts that are or may be energized should, in addition to (a), be qualified persons who have been trained to work on energized circuits.

1.3 The proper operation of motor control centers is dependent upon handling, installation, operation and maintenance by qualified personnel. Failure to follow certain fundamental installation and maintenance requirements could lead to personal injury, the failure or loss of the motor control center, or any combination thereof, and damage to other property.

Frequently, a motor control center is split into two or more sections for shipment, with the intent that they will be joined at the point of its permanent location.

References to the *National Electrical Code* are shown as (NEC) and refer to NFPA Publication No. 70.

Reference to manufacturer, unless otherwise specified, means the motor control center manufacturer.

1.4 QUALIFIED PERSON

For the purpose of this guide, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he or she has the following qualifications:

1.4.1 *Is trained and authorized* to energize, de-energize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

1.4.2 Is trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

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Section 2
HANDLING

2.1 The following guidelines are provided to help avoid personal injury and equipment damage during handling, and to facilitate moving the motor control center at the job site.

2.1.1 Follow the manufacturer's handling instructions for the specific equipment.

2.1.2 Handle the motor control center with care to avoid damage to the components, to the frame, to the enclosure, or its finish.

2.1.3 Keep the motor control center in an upright position unless otherwise specifically permitted by the manufacturer.

2.1.4 Know the capabilities of the moving means available to handle the weight of the motor control center.

2.1.5 When the motor control center is received, unpack it sufficiently to inspect for concealed damage and to determine that the shipment is complete and correct.

2.1.6 If the motor control center is to be stored for any length of time prior to installation, restore the packing for protection during that period. Where conditions permit, leave the packing intact until the motor control center or sections are at their final installation position. If the packing is removed, cover the top and openings of the equipment during the construction period to protect them against dust and debris. (See Section 3.)

2.1.7 Keep the motor control center secured to the shipping skid to prevent distortion of the frame during moving, and to minimize tipping.

2.1.8 Exercise care during any movement and placement operations to prevent falling, or unintentional rolling or tipping.

2.1.9 Rod or pipe rollers, with the aid of pinch bars, provide a simple method of moving the motor control center on one floor level if there is no significant incline. Steady the load to prevent tipping.

2.1.10 A fork-lift truck may offer a more convenient method of handling the motor control center. It may also be used to move the motor control center between levels. Balance the load carefully and use a safety strap to secure the motor control center to the fork-lift. Motor control centers are normally front heavy and frequently top heavy.

2.1.11 When a platform elevator is not available to move the motor control center between elevations, overhead hoisting may be used. Lifting plates and eye bolts (Figure 2-1), or channels, angles or bars with lift holes (Figure 2-2) may have been provided as a permanent or removable part of the motor control center.

2.1.11.1 Use spreaders (Figure 2-1) to provide the vertical lift on lifting plates, and the eyebolts to avoid eyebolt or plate failure or crushing, or both, or otherwise damaging the motor control center frame or its finish.

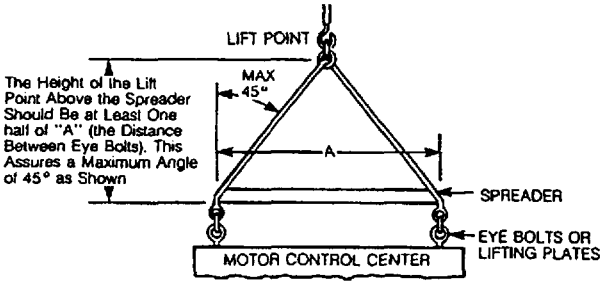


Figure 2-1
LIFTING WITH EYE BOLTS OR LIFTING PLATES

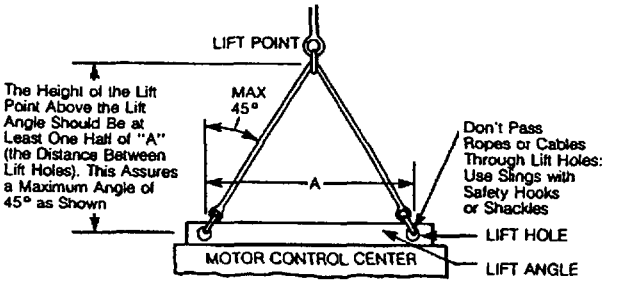


Figure 2-2
LIFTING WITH INTEGRAL LIFT ANGLE

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2.1.11.2 To reduce the stresses on the rigging or spreaders, do not allow the angle between the lifting cables and vertical to exceed 45 degrees (Figures 2-1 and 2-2).

2.1.11.3 Use slings with safety hooks or shackles. Do not pass ropes or cables through the lift holes in bars, angles, or channels.

2.1.11.4 Select or adjust the rigging lengths to compensate for any unequal weight distribution of load, and to maintain the motor control center in an upright position.

2.1.11.5 Motor control center sections that contain heavy equipment, such as transformers mounted within, could be adversely affected by tilting.

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Section 3
STORAGE

3.1 An indoor motor control center or separate unit that is not installed and energized immediately should be stored in a clean dry space where a uniform temperature prevents condensation. Preferably, it should be stored in a heated building with adequate air circulation and protected from dirt and water. Motor control centers and units should be stored where they are not subject to mechanical damage or corrosive atmosphere.

3.2 An indoor motor control center that must be stored outdoors should be securely covered for protection from weather conditions and dirt. Temporary electrical heating should be installed to prevent condensation; approximately 150 watts per section is adequate for the average motor control center's size and environment. All loose packing or flammable materials should be removed before energizing space heaters.

3.3 An unenergized outdoor motor control center should be kept dry internally by installing temporary heating (see 3.2), or by energizing self-contained space heaters.

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Section 4
INSTALLATION OF MOTOR CONTROL CENTER SECTIONS

4.1 Install the motor control center in a neat and workmanlike manner following the manufacturer's installation instructions.

4.2 Locate the motor control center in the area shown on the building floor plans. If the location is wet protect the motor control center to prevent water from entering the enclosure. Recommended clearances or working spaces are as follows:

4.2.1 Clearance from walls (not rear accessible) - minimum of 1/2 inch for indoor and 6 inches for outdoor or wet locations.

4.2.2 Clearance from front (working space). (See NEC: 110-16(a).)

4.2.3 Motor control centers installed on combustible surfaces should be equipped with steel bottom plates.

NOTE: The above space should not be used for storage; working spaces should have adequate lighting.

4.3 Securely fasten motor control centers to a level surface.

4.4 For bottom entry, position the motor control center so as to locate the conduit stubs or floor openings in the area specified on the manufacturer's drawing. In the absence of drawings, locate the motor control center over the conduits or floor openings so as to provide cable bending space and clearances to live parts. (See NEC: 373.)

4.5 Install the motor control center in its final position, progressively leveling each section and bolting the frames together if they are separate. If necessary, and permitted by the manufacturer, secure the motor control center to walls or other supporting surfaces. Do not depend for security on wooden plugs driven into holes in masonry, concrete, plaster, or similar materials. (See NEC: 110-13.)

4.6 Connect all horizontal busses at shipping breaks, using the splice busses and hardware supplied with the motor control center. Tighten bolted connections in accordance with the manufacturer's torque specifications. If the manufacturer does not provide this information, use the values in Table 7-1.

4.7 If a motor control center does not include a ground bus, provide adequate bonding between frames which are joined on the job site.

4.8 Ground and bond the motor control center as follows:

4.8.1 Motor control centers used as service equipment for a grounded system or as a main section for a separately derived system.

4.8.1.1 Connect a grounding electrode conductor, having a size in accordance with NEC: 250-94, from the grounding electrode to the motor control center ground bus or ground terminal designated by the manufacturer. (See also NEC: 250-91(a) and 250-92(a).)

4.8.1.2 If the main bonding jumper is not installed at the factory, install it from the incoming grounded conductor bus (neutral) to the ground bus or at a location designated by the manufacturer.

4.8.1.3 Steps 4.8.1.1 and 4.8.1.2 should effectively connect together the grounding electrode, the motor control center frame, all outgoing equipment grounding conductors, and the grounded neutral bus of the system (on the supply side of any disconnecting link).

4.8.1.4 Do not make any connection to ground on the load side of any neutral disconnecting link or any sensor used for ground fault protection. Do not connect outgoing grounding conductors to the neutral.

4.8.1.5 When the motor control center or system is dual fed (double-ended) and has ground fault protection, special precautions are necessary to accomplish proper grounding and bonding. Follow the manufacturer's instructions.

4.8.2 Motor control centers used as service equipment for an ungrounded system or as a main section for a separately derived system.

4.8.2.1 Connect a grounding electrode conductor, sized in accordance with NEC: 250-94, from the grounding electrode to the motor control center ground bus or ground terminal designated by the manufacturer. (See NEC: 250-91(a) and 250-92(a).)

4.8.2.2 If the system is grounded at any point ahead of the motor control center, the grounded conductor must be connected to the motor control center in accordance with NEC: 250-23(b), and connected to the ground bus or to the motor control center frame and equipment grounding terminal designated by the manufacturer.

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4.8.2.3 Steps 4.8.2.1 and 4.8.2.2 should effectively connect together the grounding electrode, the motor control center frame, all outgoing equipment grounding conductors, and any grounded conductor which is connected to the motor control center as described in 4.8.2.2.

4.8.3 Motor control centers *not* used as service equipment or as a main section for a separately derived system, and used on either a grounded or ungrounded system.

4.8.3.1 Ground the motor control center frame and any ground bus by means of equipment grounding conductors sized in accordance with NEC: 250-95 and run with the main supply conductors or by bonding to the raceway enclosing the main supply conductors in accordance with NEC: 250-91(b).

4.9 Close all unused openings in accordance with the requirements for the motor control center enclosure type.

4.10 In damp indoor locations, shield the motor control center to prevent moisture and water from entering and accumulating.

CAUTION: Hydrocarbon spray propellant and hydrocarbon-based sprays or compounds may cause degradation of certain plastics. Contact the motor control center manufacturer before using these products to clean, dry, or lubricate components during installation and maintenance.

4.11 Unless the motor control center has been designed for other than usual service conditions, it should not be located where it will be exposed to ambient temperatures above 40° C (104° F), corrosive or explosive fumes, dust, vapors, dripping or standing water, abnormal vibration, shock or tilting, or unusual conditions.

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Section 5
INSTALLATION OF CONDUIT AND WIRES

5.1 Conductors should be selected per maufacturer's instructions that are furnished with the equipment and NEC 110-14 (c).

5.2 Install conduits so that they do not provide the means for water to enter the enclosure. Bond all conduits (including stubs) to the motor control center. Locate all conduits in the areas recommended by the manufacturer to avoid cable interference with structural members and live bus.

5.3 Verify that the lugs which have been provided are suitable for use with the type of cables being installed in the motor control center.

5.4 If crimp lugs are used, crimp with the tools recommended by the lug manufacturers.

5.5 Care should be exercised in stripping insulation from the conductors to prevent nicking or ringing the conductor. For aluminum, clean all oxide from the stripped portion, immediately apply oxide inhibiting compound, and tighten all screw lugs to the manufacturer's torque values. If the manufacturer does not provide this information, use the torque values shown in Tables 7-1, 7-2, and 7-3.

5.6 Provisions should be made to locate conductors in the motor control center to avoid physical damage and overheating. Secure the conductors in order to withstand available short-circuit currents. Follow the manufacturer's instructions for lacing or bracing cables. The largest practical bending radii should be used to avoid damaging the insulation. Form the conductors to minimize stress on the terminals.

5.7 Make wiring connections in accordance with the wiring diagram and manufacturer's instructions.

5.8 Installation of conductors should be done at temperatures above freezing to prevent conductor insulation from cracking or splitting. As an alternative, use conductors that are suitable for installation at temperatures below freezing.

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Section 6
INSTALLATION OF MOTOR CONTROL CENTER UNITS

6.1 FIELD INSTALLED UNITS

Follow these instructions for field installed *units*.

6.1.1 Carefully unpack units to avoid damage.

6.1.2 Examine the units for shipping damage and verify they are the correct units for the installation.

6.1.3 Verify that correct doors are used with the units being installed.

6.1.4 Turn the circuit disconnecting means to the "OFF" position before attempting to install units.

6.1.5 Install units and doors in motor control centers by carefully following the manufacturer's instructions.

6.1.6 Make wiring connections in accordance with the wiring diagram and manufacturer's instructions.

6.1.7 When units are mounted in the rear and sections have a common vertical bus, verify that the wires to the motor leads are in proper phase sequence.

6.1.8 For unit storage instructions, see Section 3.

6.1.9 Follow instructions in Section 7 before energizing.

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Section 7
STEPS TO BE TAKEN BEFORE ENERGIZING

7.1 FOLLOW MANUFACTURER'S INSTRUCTIONS

Because of the diversity of components which may be supplied, the manufacturer's instructions should be followed.

7.2 RETIGHTEN ALL CONNECTIONS

7.2.1 Retighten all accessible electrical connections to the manufacturer's torque values. if furnished. If the manufacturer does not provide this information, tighten steel hardware parts (except pressure wire connectors and conical spring washers (Belleville)) to the values given in Table 7-1 for metal-to-metal connections.

7.2.2 Retighten the wire clamping members of all accessible mechanical (pressure wire) type connectors to the values specified by the manufacturer, if provided, or to the torque value (pound-inches) for the largest wire size the connectors will accept as given in Tables 7-2 and 7-3. According to Article 430-9 (c) of the *National Electrical Code*, control circuit devices with screw-type pressure terminals used with No. 14 AWG or smaller copper conductors are to be torqued to a minimum of seven pound-inches (0.79 N-m) unless identified for a different torque value.

7.2.3 Retighten conical spring washers (Belleville) according to manufacturer's instructions, if provided. If not provided, retighten until washer is flat.

7.3 Retighten conical spring washers (Belleville) according to manufacturer's instructions, if provided. If not provided, retighten until washer is flat.

7.4 Check the integrity of all bus mounting means.

7.5 Check the enclosure to see that it has not been damaged so as to reduce electrical spacings.

7.6 Compare all circuits for agreement with the wiring diagram which accompanies the motor control center.

7.7 Verify that field wiring is adequately separated from live busses. Physically secure the field wiring to withstand the effects of fault currents.

7.8 Check to determine that all grounding connections are made properly. If there is no ground bus, make certain that the sections of the motor control center which are shipped separately are connected in such a way as to assure a continuous grounding path.

7.9 Check all devices for damage. Make all necessary repairs or replacements, prior to energizing.

7.10 Verify that each motor is connected to its intended starter and according to the NEC.

Table 7-1*
RECOMMENDED TORQUE VALUES FOR METAL-TO-METAL ELECTRICAL CONNECTIONS

Bolt	Diameter	Tightening Torque
#8	(5/32")	15 pound-inches
#10	(3/16")	20 pound-inches
	1/4"	7 pound-feet
	5/16"	12 pound-feet
	3/8"	20 pound-feet
	1/2"	50 pound-feet
	5/8"	95 pound-feet
	3/4"	155 pound-feet

*For motor control centers designed for use under usual service conditions as defined in NEMA Publication ICS 1 Clause 6, the torque values in Tables 7-1, 7-2, and 7-3 may be used. For unusual service conditions, consult the manufacturers.

7.11 Manually exercise all switches, circuit breakers, and other operating mechanisms to make certain that they operate freely.

7.12 Electrically exercise all electrically operated switches, circuit breakers, and other mechanisms to determine that the devices operate properly. An auxiliary source of control power will be necessary to provide power to the electrical operators.

7.13 Test the ground fault protection system (if furnished) in accordance with the manufacturer's instructions.

7.14 Set any adjustable current and voltage trip mechanisms to the proper values. Experience has indicated that damage from faults can be reduced if the devices used for short-circuit and ground fault protection are set to operate instantaneously (that is, without intentional time delay), at 115 percent of the highest value of phase current that is likely to occur as the result of any anticipated motor starting currents.

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Table 7-2*
TORQUE VALUES, POUND-INCHES (SI UNITS)
SLOTTED HEAD SCREW DRIVER No. 10 AND LARGER SCREWS

Wire Size Installed, AWG or KCMIL	Slot Width 3/64 and Less Slot Length 1/4 and Less (SI Units)	Slot Width Over 3/64 Slot Length Over 1/4 (SI Units)	External Drive Wrench	
			Split Bolt (SI Units)	Other (SI Units)
14	20 (2.3)	35 (4.0)	80 (9.0)	75 (8.5)
12	20 (2.3)	35 (4.0)	80 (9.0)	75 (8.5)
10	20 (2.3)	35 (4.0)	80 (9.0)	75 (8.5)
8	25 (2.8)	40 (4.5)	80 (9.0)	75 (8.5)
6	35 (4.0)	45 (5.1)	165 (18.6)	110 (12.4)
4	35 (4.0)	45 (5.1)	165 (18.6)	110 (12.4)
3	35 (4.0)	50 (5.6)	275 (31.1)	150 (16.9)
2	40 (4.5)	50 (5.6)	275 (31.1)	150 (16.9)
1	...	50 (5.6)	275 (31.1)	150 (16.9)
1/0	...	50 (5.6)	385 (43.5)	180 (20.3)
2/0	...	50 (5.6)	385 (43.5)	180 (20.3)
3/0	...	50 (5.6)	500 (56.5)	250 (28.2)
4/0	...	50 (5.6()	500 (56.5)	250 (28.2)
250	...	...	650 (73.5)	325 (36.7)
300	...	...	650 (73.5)	325 (36.7)
350	...	...	650 (73.5)	325 (36.7)
400	...	...	825 (93.2)	325 (36.7)
500	...	...	825 (93.2)	375 (42.4)
600	...	...	1000 (113.0)	375 (42.4)
700	...	...	1000 (113.0)	375 (42.4)
750	...	...	1000 (113.0)	375 (42.4)
800	...	...	1100 (124.3)	500 (56.5)
900	...	...	1100 (124.3)	500 (56.5)
1000	...	...	1100 (124.3)	500 (56.5)
1250	...	...	1100 (124.3)	600 (67.8)
1500	...	...	1100 (124.3)	600 (67.8)
1750	...	...	1100 (124.3)	600 (67.8)
2000	...	...	1100 (124.3)	600 (67.8)

*For motor control centers designed for use under usual service conditions as defined in NEMA Publication ICS 1, Clause 6, the torque values in Tables 7-1, 7-2, and 7-3 may be used. For unusual service conditions, consult the manufacturer.

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The magnetic trip value of the instantaneous trip circuit breakers should not exceed the values specified in NEC Article 430-52.

7.15 Ensure that overload relays or heater elements are installed and selected or adjusted or any combination thereof to the full load current shown on the nameplate of each motor and the manufacturer's instructions.

7.16 Install power circuit fuses in the fusible switches in accordance with NEC 430-52 application requirements. Make sure that fuses are completely inserted in the clips. Do not attempt to defeat the rejection features on the fuse clips, when provided.

7.17 Remove shorting bars from the secondary of current transformers. Do not operate a current transformer with its secondary circuit open.

7.18 To prevent possible damage to equipment or injury to personnel, check to insure that all parts and barriers that may have been removed during wiring and installation have been properly reinstalled.

7.19 Before closing the enclosure, remove all metal chips, scrap wire, and other debris from the motor control center interior. If there is appreciable accumulation of dust or dirt, clean out the motor control center by using a brush, vacuum cleaner or clean, lint-free rags.

Do Not Use Compressed Air Because It Will Redistribute Contaminant On Other Surfaces.

7.20 Conduct an electrical insulation resistance test to verify that the motor control center and field wiring are free from short circuits and grounds. Test phase-to-ground, phase-to-phase, and phase-to-neutral, with the switches or circuit breakers opened.

7.21 Install covers, close doors, and make certain that no wires are pinched and that all enclosure parts are properly aligned and tightened.

7.22 Turn all circuit breakers and fusible switches to the "OFF" position before energizing the bus.

Table 7-3*
HEX SOCKET SCREWS

Socket Size (Across Flats), Inches (mm)	Tightening Torque Pound-Inches (SI Units)
1/8 (3.2)	45 (5.1)
5/32 (4.0)	100 (11.3)
3/16 (4.8)	120 (13.6)
7/32 (5.6)	150 (16.9)
1/4 (6.4)	200 (22.6)
5/16 (7.9)	275 (31.1)
3/8 (9.5)	375 (42.4)
1/2 (12.7)	500 (56.5)
9/16 (14.3)	600 (67.8)

*For motor control centers designed for use under usual service conditions as defined in NEMA Publication ICS 1, Clause 6, the torque values in Tables 7-1, 7-2, and 7-3 may be used. For unusual service conditions, consult the manufacturer.

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Section 8
ENERGIZING EQUIPMENT

8.1 Energizing a motor control center for the first time is potentially dangerous. Therefore, only qualified personnel (see Section 1.3) should energize the equipment. If faults caused by damage or poor installation practices have not been detected in the checkout procedure described in Section 7, serious damage or personal injury, or both can result when the power is applied to the motor control center and its connected loads.

8.2 In order to minimize risk of injury or damage, or both, there should be no load on the motor control center when it is energized. Turn off all of the downstream loads, including those such as distribution equipment and other devices which are remote from the motor control center.

8.3 Energize the equipment should be energized in sequence by starting at the source end of the system and working toward the load end. Energize in the following sequence:

a. Main Devices

b. Feeder Devices

c. Branch Circuit Devices

Operate disconnecting device handles with a firm, positive motion, do not attempt to "tease" into the closed position.

8.4 After all disconnect devices have been closed, energize loads such as lighting circuits, starters, contactors, heaters, and motors.

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Section 9
PERMISSIBLE LOADING OF MOTOR CONTROL CENTERS

9.1 For motor control centers with incoming line lugs, the total continuous load current through the horizontal bus should not exceed the current rating of the motor control center.

9.2 For motor control centers with a single main overcurrent protective device, or a main isolating device, the total continuous load current on the protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

9.3 For motor control centers with multiple main overcurrent protective devices, the total continuous current through the horizontal bus should not exceed the current rating of the motor control center.

The total continuous load current on each overcurrent protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

9.4 For a branch-circuit overcurrent protective device in a motor control center, the total continuous load current on the protective device should not exceed 80 percent of its ampere rating unless the device is rated to carry 100 percent of its ampere rating.

9.5 The maximum short circuit current rating of the entire motor control center should be the smallest of the following:

a. The rating of the bus system or structure

b. The lowest rating of the motor control units

c. The lowest rating of the feeder tap units

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Section 10
CARE AND MAINTENANCE

10.1 A periodic maintenance program should be established. NFPA Publication 70B (*Electrical Equipment Maintenance*) may be used as a guide for establishing such a program. For other than usual service conditions listed in NEMA ICS 1, Clause 6, or any other unusual service conditions, consult the manufacturer's maintenance instructions.

10.2 Because of the diversity of components which may be supplied, the manufacturer's instructions should be consulted for required maintenance, wear, or degradation of components.

10.3 Carefully inspect the doors, enclosure sides and deadfront surfaces over all units for evidence of excessive heat. As a general rule, a temperature which the palm of the hand cannot stand for about three seconds may indicate trouble.

Disconnect power ahead of the motor control center and lockout or tag out, or both, circuits and equipment in accordance with NFPA 70E Part II, before performing any of the following operations. Discharge capacitors, if present. Positively verify that the equipment is totally de-energized, by using an appropriate instrument, such as a voltmeter. When separate control circuits exist, verify that they also are de-energized.

Where it is not feasible to de-energize and lockout or tag out or both, circuits or equipment, the requirements of Section 1 of this guide become extremely important.

10.4 Inspect the motor control center at least once each year, or more often as deemed necessary.

10.4.1 Examine the inside of the motor control center for moisture, signs of previous wetness, or dripping. Water from condensation in conduits is a common cause of motor control center failure.

Caution: Hydrocarbon spray propellant and hydrocarbon-based sprays or compounds may cause degradation of certain plastics. Contact the motor control center manufacturer before using these products to clean, dry, or lubricate components during installation and maintenance.

10.4.1.1 Seal off any conduits that have dripped condensate, and provide an alternative means for the conduit to drain.

10.4.1.2 Seal off any cracks or openings which have allowed moisture to enter the enclosure. Eliminate the source of any dripping on the enclosure.

10.4.1.3 Replace or thoroughly dry and clean any insulating material which is damp or wet or shows accumulation of deposited material from previous wettings. Conduct an electrical insulation resistance test to verify the dielectric integrity of the affected insulation.

10.4.1.4 Check devices such as contactors, circuit breakers, disconnect switches, relays, pushbuttons, etc., for wetness, contamination, or corrosion, and replace or clean and dry as required and according to the manufacturer's instructions.

10.4.1.5 *Be sure* that the *cause* of any wetness or contamination has been *identified* and *eliminated.* If the cause is internal condensation, it may be necessary to provide supplementary heating; consult the manufacturer.

10.4.1.6 In the event of water damage, i.e., flooding or sprinkler discharge, the manufacturer should be consulted before clean up and corrective action is attempted or before the equipment is re-energized. General instructions can be found in the NEMA publication entitled, "*Guidelines for Handling Water Damaged Electrical Equipment.*"

10.4.2 Remove accumulated dust or dirt by using a brush, vacuum cleaner, or clean lint-free rags.

Do not use compressed air because it will only redistribute contaminant on other surfaces.

10.4.3 Examine all accessible electrical joints and terminals in the bus and wiring systems for signs of overheating or corrosion.

10.4.3.1 Retighten bolts and nuts at bus joints, if there is any sign of overheating or looseness. See Section 7.

10.4.3.2 If joints or terminations are badly discolored, corroded or pitted, the parts should be disassembled and replaced or cleaned. Emery paper, sand paper, or a file should not be used to clean or dress up any portion of the electrical equipment. For unplated copper bus applications requiring a sanding operation use aluminum oxide paper. This will not leave sand or metal particles on contact surface areas. Do not sand aluminum bus under any circumstances.

Consult the manufacturer for cleaning procedures appropriate for the bus and termination material. Do not remove plating on aluminum parts in joints or terminations. Damaged aluminum parts should be replaced.

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10.4.3.3 Examine all wire or cable connections for evidence of looseness or overheating. Retighten, if necessary. If major discoloration of cable insulation or if cable damage is apparent, replace the damaged portion of the cable.

10.4.3.4 Examine fuse clips. If there is any sign of overheating or looseness, check the spring pressure, tightness of clamps, etc. Replace the fuse clips if the spring pressure compares unfavorably with that of other similar fuse clips in the motor control center. Make sure that fuses are completely inserted.

10.4.3.5 Look for any signs of deterioration of insulating material or melting of the sealing compound. Replace such insulating parts, and assemblies where sealing compound has melted. Make sure the dielectric integrity of the affected parts has been maintained.

10.4.3.6 Be sure that the condition that caused the overheating has been corrected.

10.4.4 Check for the proper operation of all mechanical components.

10.4.4.1 Check all switch operator mechanisms and external operators of circuit breakers. Make sure each operator mechanism quickly and positively throws contacts to the fully "ON" and fully "OFF" positions.

10.4.4.2 Examine the operation of all electrical and mechanical interlocks and padlocking means. If necessary, adjust according to the manufacturer's instructions.

10.4.4.3 Check all devices for missing or broken parts, proper spring tension, free movement, rusting or corrosion, dirt, and excessive wear. If necessary, replace, repair, clean, lubricate, or adjust or any combination thereof, according to the manufacturer's instructions.

10.4.5 Examine all readily accessible arc chutes and insulating parts for cracks or breakage and for arc splatter, sooty deposits, oil or arc tracking.

10.4.5.1 Clean off arc splatter, oil and sooty deposits, and inspect for burning, charring, or carbon tracking. To determine whether such wear requires replacement, consult the manufacturer's instructions.

10.4.5.2 Replace insulating parts and arc chutes that are cracked or broken.

10.5 Operate each switch or circuit breaker, several times, to make sure that all mechanisms are free and in proper working order. If it is desirable to verify the performance of molded case circuit breakers, follow the manufacturer's instructions.

10.6 Check fuses and circuit breakers to make sure they have the proper ampere rating, type and interrupting rating. Make sure that non-current-limiting fuses are never used as replacements for current-limiting fuses. Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

10.7 Verify the vacuum integrity of a vacuum interrupter by performing a high potential dielectric test, following the manufacturer's instructions.

Care should be taken not to apply a test voltage that exceeds the manufacturer's recommendation across the open contacts of a vacuum type interrupter, to avoid generating harmful x-rays.

10.8 Verify that wiring, grounding, installation and functional adjustments for solid state industrial controllers, such as variable speed drives, programmable controllers, and the like, are made in accordance with the manufacturer's recommendations.

10.9 Inspect to ensure that oil or grease (if used) is applied only to surfaces recommended by the manufacturer.

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Section 11
MAINTENANCE AFTER A FAULT HAS OCCURRED

11.1 After a fault has occurred, all equipment should be de-energized, disconnected, and isolated to prevent accidental contact with live parts. To verify that this has been done, check voltage on all control terminals and on all line and load terminals of circuit breakers, disconnect switches, and starters or contactors before touching or working on equipment. Only qualified personnel should perform the inspection and repair procedure and all safety procedures should be observed.

The excessive currents occurring during a fault may cause damage to structure, components or bus, or any combination thereof, and conductor damage due to mechanical distortion, thermal damage, metal deposits, or smoke. After a fault, repair the cause of the fault, inspect all equipment per NEMA Standards Publication No. ICS 2, Annex A, *Maintenance of Motor Controllers After a Fault Condition*, and make repairs or replacements prior to putting the equipment in service again. Verify that all replacements (if any) are of the proper rating and are suitable for the application. If in doubt, consult the manufacturer. The following procedures are recommended for this inspection.

11.2 BUS

Retighten all bus connections as per Section 7. Replace damaged or deformed busses and fasteners, or busses with melted, worn, or damaged plating (see Section 10). Replace all insulators showing damage, deterioration, or deposits, and perform an electrical insulation resistance test to verify the electrical integrity. Verify minimum spacings through air and over surface between live parts and grounded metal parts in accordance with Part 1, Clause 7 of NEMA Standards Publication No. ICS 3.

11.3 PLUG-IN (STAB-ON) ASSEMBLIES

Inspect stab-on clips for evidence of arcing, melting, erosion, deformation, or general heat damage. Replace the complete stab-on assembly if there is evidence of damage.

11.4 ENCLOSURE

External enclosure deformation usually indicates damage within. Extensive damage will require replacement of the enclosure parts and the enclosed equipment. The procedure described below may be used to arrive at decisions regarding these replacements.

In addition to inspecting the enclosure and doors for evidence of damage such as deformation, displacement of parts, or burning, ensure that door-mounted equipment and safety interlock function correctly. Confirm that hinge and latch integrity is maintained.

11.5 DISCONNECTING MEANS

11.5.1 CIRCUIT BREAKERS

Examine the circuit breaker for evidence of possible damage. If there is no apparent evidence of damage, the breaker may be reset and turned "ON" using the external handle. If it is suspected that the circuit breaker has opened several short circuits or if there are signs of possible deterioration, replace the breaker.

11.5.2 DISCONNECT SWITCH

After a fault, the external operating handle should be capable of opening the switch. Replace the switch if the external operating handle fails to open it, or if visual inspection after opening indicates deterioration beyond normal wear, such as overheating, arc chute damage, contact blade or jaw pitting, charring, welding or insulation breakage.

11.5.3 FUSE HOLDERS

Replace fuse holders if the insulating mounts, barriers, or fuse clips show signs of damage, deterioration, heating, distortion or looseness.

11.5.4 OPERATING HANDLE

The disconnection means and external operating handle should be replaced if the operating handle fails to open or close the switch or circuit breaker. The door interlock should be inspected and its proper functions verified prior to restoring the controller to service.

11.5.5 Operate each switch or circuit breaker several times to make sure that all mechanisms are free and in proper working order. To verify the performances of molded case circuit breakers, follow the manufacturer's instructions.

11.5.6 Verify that non-current-limiting fuses are never used as replacements for current-limiting fuses. Examine fuses and circuit breakers have the proper ampere rating, type, and interrupting rating. Never attempt to defeat rejection mechanisms which are provided to prevent the installation of the wrong type of fuses.

11.5.7 Inspect to ensure that oil or grease, if used, is applied *only* to surfaces recommended by the manufacturer.

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11.6 TERMINALS AND INTERNAL CONDUCTORS

Replace all damaged parts which show evidence of discoloration, melting or arcing damage.

11.7 MOTOR STARTER

11.7.1 CONTACTOR

Replace the contacts and contact springs if the contacts are welded or show heat damage, displacement of metal, evidence of binding in the guides, or wear in excess of wear allowance. If deterioration extends beyond the contacts, replace the contactor or starter. Examples of such deterioration include evidence of arcing on the contactor moldings and insulation damage. Perform an electrical insulation resistance test to verify electrical integrity.

11.7.2 OVERLOAD RELAYS

11.7.2.1 If burnout of a heater element has occurred, the heater element should be replaced, and it may be necessary to replace the overload relay or the starter; refer to the manufacturer's instructions. Any indication of an arc striking or burning the overload relay calls for replacement.

11.7.2.2 If there is no visual indication of damage that would require replacement, contact operation should be verified by electrically or mechanically tripping and resetting the overload relay.

11.7.3 FUSES

Always replace all fuses in a multi-phase circuit, even though only one or two are open circuited. Internal damage suffered by the unreplaced fuses could result in a shut-down later.

11.8 Before restoring the equipment to service, perform the *Steps to be Taken before Energizing* procedures detailed in Section 7 of this manual.

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